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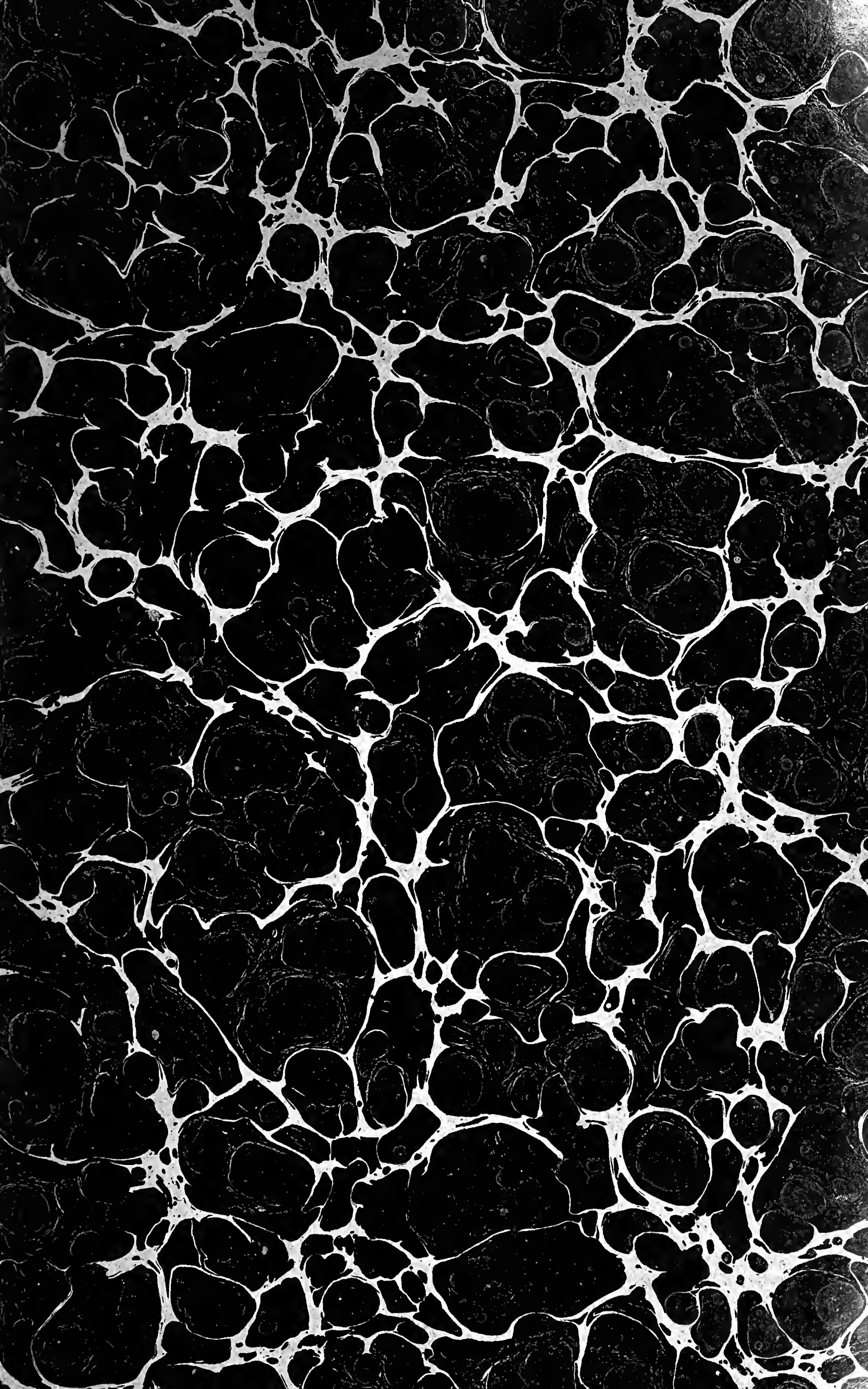
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FOREST PLANTING LEAFLET NO. 1.

**HOW TO CULTIVATE AND CARE FOR FOREST PLANTATIONS ON
THE SEMI-ARID PLAINS.**

OBJECTS OF CULTIVATION.

Successful forest planting on the Plains, where the rainfall is light or irregular and the evaporation great, depends largely upon the proper tillage of the soil. The region possesses a deep, rich, easily-worked soil, which the farmers are learning how to utilize to the best advantage. The early tree planters often set their trees carelessly, and left them to struggle with the native vegetation and dry weather. Planters are now beginning to realize that trees as well as agricultural crops respond to good cultivation.

The objects of cultivation are two: First, to prevent the growth of weeds and grass; second, to conserve the soil moisture. The natural supply of moisture on the plains is sufficient for the growth of many species of trees, provided it is fully utilized and not allowed to escape through evaporation or to be appropriated by weeds and grass.

TREATMENT OF THE SOIL.

Before the trees are set, the ground should be thoroughly worked and put in good condition. Virgin sod should be broken and the land farmed for two or three years. Deep plowing, followed immediately by the harrow, saves moisture and makes the soil easily penetrable by the roots. After the trees are set there should be frequent shallow cultivation. An ideal method is to cultivate as soon as practicable after every rain, in order to maintain a dust mulch over the surface. The nearer this ideal is approached, the better the results will be. The dust mulch is the best medium to conserve the moisture already in the ground, and to keep the soil in condition to absorb the next rain.

MULCHING.

A mulch of hay, straw, or well-rotted manure may be used where cultivation is not feasible, but it is not to be generally recommended. The mulch retards the growth of weeds, checks evaporation, and prevents baking of the soil, but if continued long it causes the roots to grow close to the surface, so that when the litter is removed they are liable to be damaged by the exposure. The mulch has another disadvantage in that it furnishes a congenial harbor for mice and all kinds of insects.

A mulch of hay or straw is less objectionable around trees set in the sod, where it is inconvenient or undesirable to cultivate. Along a hedge row, for instance, a mulch may be of great benefit.

SPACING THE TREES.

The advantage to be gained by continued cultivation of a forest plantation makes rather wide spacing advisable, even though certain species which have a spreading habit may require pruning so that the trunks may grow clear and the cultivation not be impeded. Compensation for the wide spaces between the rows can be secured in large measure by setting the trees closer in the rows. The spacing of many plantations is 4 feet by 4 feet, but trees set in that way can be cultivated only two or three years. Spacing 2 feet by 8 feet gives the same number of trees to the acre, and makes it possible to continue the cultivation much longer. Species which need more room can be set 3 feet by 8 feet or 4 feet by 8 feet, and, as they grow, the space required can be obtained by removing the less promising individuals. The less cultivation that is to be given a plantation the closer the trees should be set; for, in the absence of artificial methods of conserving the soil moisture, the stand itself must be dense enough to shade the ground and furnish a litter which will maintain the proper moisture conditions. Without this the trees will neither grow rapidly nor preserve their vigor. On the semi-arid plains, however, wide spacing and frequent cultivation will produce better trees than close spacing and little cultivation.

SITUATIONS WHERE CULTIVATION IS UNNECESSARY.

In river and creek valleys, where water is found at from 5 to 20 feet below the surface, cultivation is not ordinarily necessary after the trees are thoroughly established. The same is true in many places on the upland, where shallow depressions catch the run-off from considerable adjoining areas. In such situations the supply of water may be concentrated on any desired part of the depression by running furrows to it from the surrounding slopes. This method has been successfully used by some of the most progressive western farmers.

FALL CULTIVATION HARMFUL.

Cultivation should not be continued too late in the fall, for it tends to produce tender young shoots after the normal growth has ceased, which may not be able to withstand the winter. The wood should have time to harden before cold weather sets in. If the ground has been kept clean, weeds will give little trouble after the middle of August.

PLANTING CROPS WITH TREES.

The planting of field crops between rows of young trees on the plains is unwise; the trees need all the available moisture. Corn is especially harmful, because the roots spread both down and out from 5 to 8 feet,

and take much more soil moisture than the young trees. If any crop is planted it should be a short-lived one of the garden kind, whose roots do not spread far and are soon gone.

TOOLS—METHODS OF CULTIVATION.

The plow has no place among trees, other than to prepare the ground for planting. The plantation is often neglected until the weeds have formed a dense growth 3 or 4 feet high, and then the ground between the rows is plowed. The plow leaves the ground rough, a condition which greatly increases the loss of soil moisture through evaporation. Dead furrows are formed between the rows, or the earth is thrown away from the bases of the trees and many roots are cut, which does great injury to the trees.

The best implements for the cultivation of the ground are the pulverizing harrow, the disk harrow, the dagger-tooth harrow, and the five-tooth cultivator. The pulverizing harrow is an excellent tool for shallow tillage, and, when used frequently enough, is all that is necessary. Where the weeds are large, an ordinary cultivator may be put in or a shallow disking given, but to give the best surface conditions the disk should be set quite slanting or be followed by a harrow. A single section of a dagger-tooth harrow drawn by one horse may be used advantageously between the rows of trees. The five-tooth, one-horse cultivator requires the least space of any of the tools mentioned, and can be used when the rows are close together or after the trees have grown so as to fill most of the space between the rows.

Care should always be taken that the stems of the trees are not injured in any way. There should be no projecting parts about the cultivator or the harness, but if such parts are unavoidable they should be wrapped with pieces of old sacks.

GRAZING—FIRE.

Grazing animals should be rigorously excluded from all tree plantations. Even if the trees are too large to be broken off by the stock, every branch within reach will be browsed, and the desirable forest conditions of shade, undergrowth, and litter will be destroyed. In a well-established grove, stock may do little harm, but until the crowns of the trees are entirely out of reach, cattle should not be admitted. Even then injury may result from the trampling of the soil. A heavy soil becomes packed so that it is nearly impervious to water, while a sandy one is worn and blown away, leaving the roots exposed. The damage to large trees in situations where moisture is abundant is not usually great, and the protection furnished to stock in such a case may more than offset the slight injury to the trees.

Every tree plantation needs to be protected by some form of fire guard. Where conditions permit, a very satisfactory guard is made by

plowing two or three furrows about the plantation close to the trees, and then making a second series of furrows from one to two rods outside the first. These lines may be kept free from vegetation by reploting each year, or they may be used for crops that do not easily burn. The space between the two series of furrows should be kept free of all combustible material by burning it over at safe times.

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FOREST PLANTING LEAFLET NO. 2.

HOW TO PACK AND SHIP YOUNG FOREST TREES.

The success of a forest plantation depends largely upon the care that is exercised in handling the seedlings during the time they are out of the ground. If the following directions are carefully followed, young trees may be safely transported with little risk of serious loss, though it should be remembered always that the longer the plants are exposed the greater is the danger of injury, since damage is done mainly by the drying out of roots. To maintain some moisture about the roots is therefore the chief care.

CONIFEROUS SPECIES.

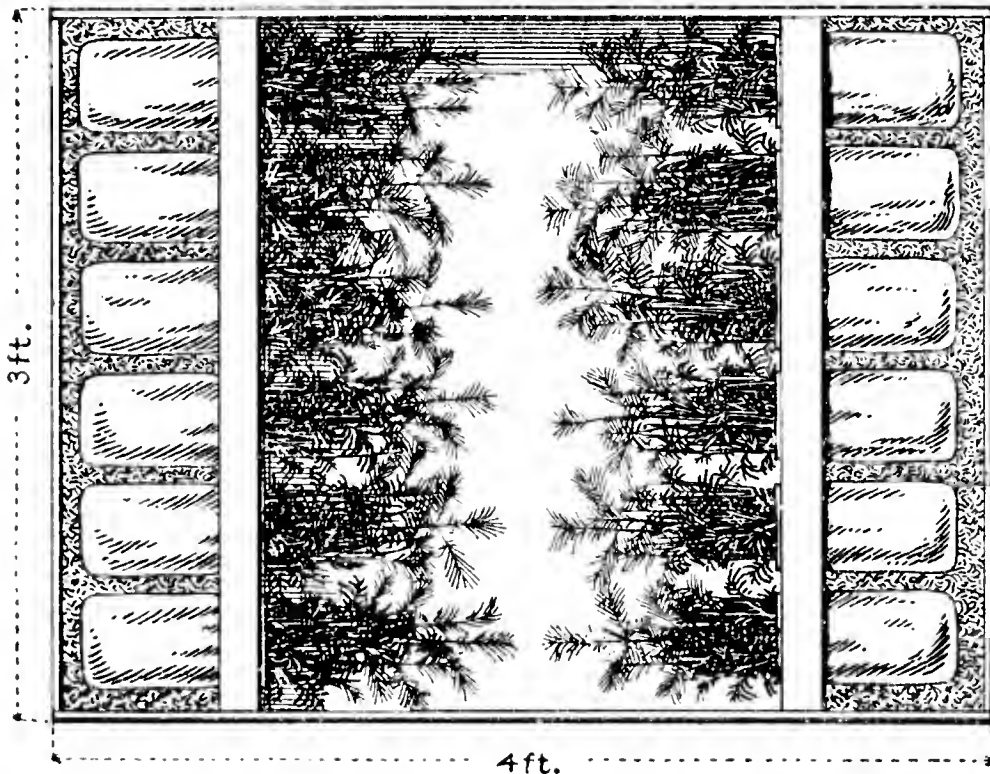
Evergreen or coniferous seedlings are much more subject to drying out than those of broadleaf trees, because their foliage is always active, while in the latter, the surface from which transpiration may take place is greatly reduced during the leafless season.

Coniferous trees for forest planting, except a few species, should not be more than 4 or 5 years old, or not more than 10 inches high. Much smaller trees, from 1 to 3 years old, are usually preferable. Larger trees are costly, hard to move without being injured, and difficult to establish in a new situation.

As soon as the seedlings are taken from the ground the roots should be dipped into a "puddle" of thin mud. Bundles of 50 or 100 should then be made, and the roots of the plants covered with moist sphagnum moss, which, in turn, should be wrapped about with several layers of thick paper. The paper assists greatly in preventing the evaporation of moisture from the bundle. After this, each bundle should be tied about the middle with twine or raffia fiber, care being taken not to draw the cord tight enough to injure the seedlings. The bundles should then be placed in a box wide enough to admit several bundles side by side, and long enough to hold two bundles laid end to end, with a space of a few inches between the tops. A tier of bundles should be placed on the bottom of the box, with the roots next the ends and the foliage toward the middle. Across the middle of each row should be placed a cleat, about 1 inch thick and 2 inches wide, secured in position by nails driven into its ends from without. Above the first tier of bundles a second should be laid and secured in the same way; then a third, and so on until the box is full or the required number of plants have been packed. (See fig. 1.)

Further to insure the retention of moisture about the roots, the spaces between the root wrappings should be filled with wet chaff or moss, but the spaces between the tops should be left empty. After the box has been nailed up, two or three holes should be bored into the sides so that the air may circulate freely. Seedlings packed in this way will remain in good condition for several weeks, but the box should be kept

Top View



Side View

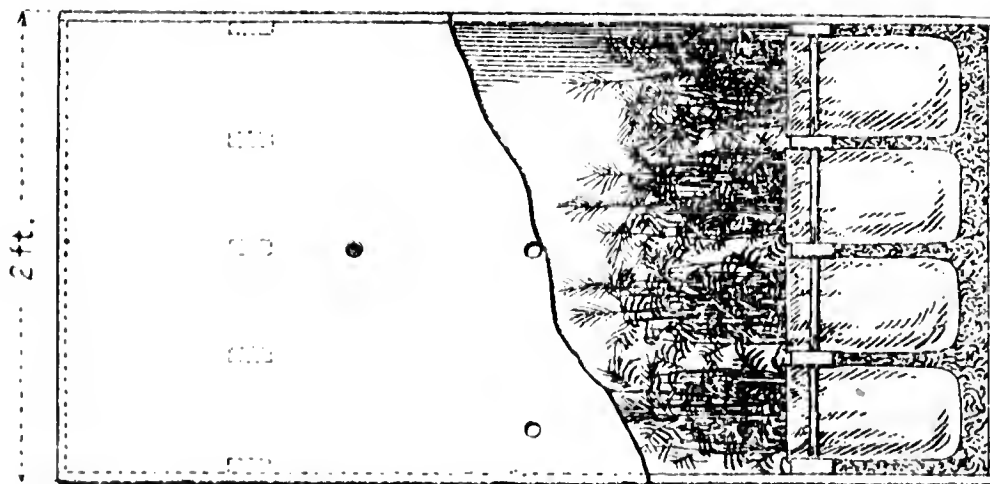


FIG. 1.—Method of packing young forest trees.

DECIDUOUS SPECIES.

Deciduous trees are best transplanted when not over 2 feet high, and should always be moved when the leaves are off.

For long-distance shipment the seedlings should be wrapped and boxed in the manner described for conifers, although the greater bulk of the plants usually necessitates putting a smaller number of seedlings in each bundle. For shipment only a short distance, it often suffices to surround the roots with wet chaff and a wrapping of burlap.

Deciduous or broadleaf trees will withstand harder usage than evergreens, yet all kinds repay careful treatment while being transplanted.

from the sun and opened as soon as possible.

Where sphagnum moss is not available, the roots may be wrapped in wet burlap, fine wet chaff, or sawdust which has undergone fermentation. With all these, however, extra care must be taken to cover the wrapping with paper.

When the trees are to be transported only a short distance by wagon, less care is necessary. The bundles should be made up as described, but may be set upright in shallow, open boxes.

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FOREST PLANTING LEAFLET NO. 3.

BUR OAK (*Quercus macrocarpa*).

FORM AND SIZE.

The bur oak is one of the largest trees found in central North America. It frequently attains a height of from 80 to 90 feet, and a diameter of from 3 to 4 feet. Under the most favorable conditions it has reached a height of 170 feet and a diameter of 7 feet. When grown free the crown is large and heavy; in the forest it is usually contracted and covers only the upper part of the tree.

The distinguishing feature of the bur oak is that from which it gets its name—the mossy fringe about the rim of its deep acorn cup. The leaf is large and deeply lobed and resembles that of the white oak. When the twigs are from three to four years old they begin to develop corky wings, which sometimes attain a width of an inch or more. These disappear as the branch grows older, and consequently are seen only on the younger growth.

RANGE.

The natural range of the bur oak is from Manitoba to Texas, and eastward to the Atlantic coast. It is commonest and most important in the lowland forests of the Mississippi basin, where it is found associated with white oak, basswood, white ash, cottonwood, black walnut, and several hickories. In the Dakotas and about the Great Lakes it sometimes occurs in pure stands, forming the characteristic “oak openings.” East of the Allegheny Mountains it is comparatively rare and local, and near the northern and northwestern limits of its range it dwindles to a mere shrub. Bur oak may be planted on good soils almost anywhere east of the ninety-eighth meridian, and in favorable situations somewhat farther west.

SILVICAL QUALITIES.

The bur oak is best suited to deep, rich, river-bottom soils. It will maintain itself in poorer upland localities, but it is recommended for planting only where the soil is fairly good, moist, and well drained, and where protracted droughts are infrequent. It is rather intolerant of shade, and will not thrive beneath the crowns of taller trees.

The rate of growth, except under the best conditions, is somewhat slow, and is about like that of white oak. Neither grows so rapidly as red oak. The bur oak is subject to comparatively few pests or diseases.

ECONOMIC USES.

The bur oak is one of the most valuable hardwood trees in North America. The wood is heavy, hard, very strong, and durable. In the markets it is not, and need not be, distinguished from white oak, and it is used for the same purposes. The heartwood makes especially good fence posts and railroad ties, but the sapwood does not last long in the ground.

The tree is highly desirable for planting about the home, as well as for general forest planting where quick growth is not important.

METHODS OF PROPAGATION.

The bur oak reproduces freely both by acorns and by stump sprouts. The acorns, like those of all the white oaks, mature in one season, and germinate soon after falling, unless they are collected and cared for. They should therefore be planted, if possible, in the fall, either in seed-beds or in their final place. Mice and squirrels are fond of acorns, and sometimes destroy plantations made in the fall. Where this is to be feared, or where for any other reason it is necessary to hold them over until spring, the acorns may be stored between layers of moist sand.

To secure vigorous sprouts the trees should be felled between November and March, and the stumps should be cut low and left smooth and slanting on top. Sprouts then start close to the ground, where they can soon develop root systems of their own and become self-supporting. The slanting stump causes the rain water to run off, and thus helps to prevent rapid decay.

The bur oak has one well-developed taproot, and, in moderately rich and moist soils, many spreading secondary roots close to the surface. In dry soils the roots seek moisture at considerable depths.

PLANTING.

It is usually advisable to plant acorns in their permanent place in the field, for, like all oaks, the bur oak is not easy to transplant when once fairly established, because of its stout taproot.

Where the area to be seeded can not be plowed, the acorns should generally be planted in holes about 4 feet apart each way, although the proper distance will depend to some extent upon local conditions. Three or four acorns should be placed in each hole and covered with about 1½ inches of earth. If the planting is done on plow land, the soil may be prepared as for any field crop.

Bur oak can be grown in pure stands, but it is often desirable to mix one or two slower-growing species with it, in order to force the trees to grow tall and to clear the stems of their lower branches.

Bur oak should not be planted with trees which grow very rapidly, nor where the climate is so dry that the soil needs much cultivation to preserve its moisture. Care should be taken to keep the little trees from being smothered by grass and weeds, to keep out stock and fire, and to let the plantation acquire the character of a forest as soon as it can. Weeds and litter on the ground, and shrubs that stand below the crowns of the trees, are good and should not be interfered with.

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FOREST PLANTING LEAFLET NO. 4.

JACK PINE (*Pinus divaricata*).

FORM AND SIZE.

Jack pine usually attains a height of from 30 to 50 feet, and a diameter of from 8 to 12 inches. Under favorable conditions a height of 90 feet and a diameter of 2 feet may be reached. It has a fairly straight and symmetrical stem, and, when grown free, a low, full crown. In close stands the crown is narrow and covers only the upper part of the tree. The needles are 1 to 1½ inches long and grow in pairs, bound by a short sheath.

RANGE.

The natural range of jack pine is along the northern border of the United States, from eastern Maine to Minnesota. In the United States it is commonest in northern Michigan, Wisconsin, and Minnesota, where it occupies great areas of barrens, or is found with red pine or with stunted oaks and other broadleaf species.

The tree is recommended for planting in the north-central States, where the soil is poor but contains moisture not far below the surface.

SILVICAL QUALITIES.

Jack pine is a very hardy tree, and is suited to sterile, sandy soils. It can be planted with a good prospect of success where few other trees grow, provided ground water is not too far below the surface. It will withstand considerable drought, and is rarely injured by frost. It is intolerant of shade at all ages, and therefore not well adapted for mixed plantations.

It is one of the most rapid-growing pines, but is comparatively short-lived, reaching maturity in about 60 years.

Jack pine suffers little from insects or disease. Wind will sometimes overthrow the trees, especially where the roots have been forced close to the surface of the ground by excess of moisture.

ECONOMIC USES.

The wood is light, soft, coarse-grained, moderately strong, and moderately durable. It makes good coarse lumber, and, when chemically treated, very satisfactory posts and ties. In most of its qualities it compares with the loblolly pine of the southeast. It is somewhat infer-

ior to red (Norway) pine and western yellow pine. Jack pine is a good tree for windbreaks and shelterbelts, and for farm woodlots in the Dakotas, Nebraska, and throughout the sandy regions of the north-central States, wherever a better tree will not thrive.

METHODS OF PROPAGATION.

Jack pine grows only from seed. Natural reproduction is very abundant wherever there are old trees, as a good crop of seed falls almost every year, and the percentage of germination is high. The seeds ripen in the fall, and are easily kept over winter in any dry, cool place.

Like most other pines, the tree produces a strong tap-root, which, in dry situations, may penetrate to a considerable depth. Where water is not far from the surface, as in most parts of its natural range, the deep roots are less developed, or they rot off after a time, and strong laterals are sent out in their place.

PLANTING.

In planting jack pine it is best to use seedlings two or three years old, which may be raised in nursery beds from seed planted either in the fall or in the early spring.

The young trees should be set out in the spring, late in April or early in May. They may be planted in furrows, but where the sand is light and apt to be blown about if disturbed, it will be best to place them in holes made with a spade or planting bar. As a rule the proper spacing is 4 feet each way.

It is usually advisable to plant jack pine alone, but green ash, hackberry, and possibly other hardy deciduous trees, which will not overtop it, may be introduced as associates.

CULTIVATION AND CARE.

Under ordinary conditions plantations of jack pine need little cultivation. It will often be necessary to let the young trees struggle with wild grasses, because the latter can not be removed without exposing the soil to displacement by wind. In a few years the trees will grow above and kill out the grass, and, as soon as the tops interlace, will establish good forest conditions within the plantation. Where the tree is placed about the homestead and very rapid growth is desired, the ground may be cultivated and then mulched with straw or old hay. Plantations thus made and treated will grow satisfactorily if fire and stock are kept out of them.

This pine has been planted and grown very successfully in the sand-hills of Nebraska, where the trees have received no cultivation at all. One small plantation there has produced 15 cords of wood per acre in 42 years, and the trees are still growing at a good rate.

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FOREST PLANTING LEAFLET NO. 5.

RED OAK (*Quercus rubra*).

FORM AND SIZE.

The red oak is one of the largest trees in the forests of the Northern States. The average height of mature trees is from 70 to 90 feet, and the diameter from 2 to 4 feet. Under the most favorable conditions a height of 150 feet and a diameter of 5 feet is attained. When grown free the tree has a broad and symmetrical crown and a short stem; in the forest it is tall and straight, with a small, narrow crown. On loose soil the base is often enlarged or buttressed.

RANGE.

The natural range of the red oak is from Nova Scotia to west of Lake Superior and south to eastern Kansas and northern Georgia. It is very common and well developed in the Northern and Central States, where it usually is associated with other oaks, basswood, elms, chestnut, and hickories. Toward the extreme limits of its range it becomes rare and of small size.

Red oak is recommended for planting anywhere within the limits of its natural range, on soils of medium quality, and on those which have become exhausted by cultivation.

SILVICAL QUALITIES.

Red oak is best suited to porous sandy or gravelly clay soils. In this requirement it is intermediate between the white oaks and several of the black oak group. It requires well-drained soil always, but does not do well where the air is very dry.

The tree is intolerant of shade, except when very young, and must always be allowed to keep its crown free.

Red oak surpasses all other oaks in the rapidity of its growth, and is therefore a good tree to plant where conditions are suitable.

Like the other oaks, this species is not subject to disease, nor to serious insect attacks, and is rarely overthrown by wind.

ECONOMIC USES.

The wood of red oak is heavy, hard, coarse-grained, strong, and moderately durable. It is inferior to white oak where great strength is required, and does not last so long in the ground, but it works easier,

and is often preferred for interior finish and for cabinet work. Good red oak is often sold as white oak, and for most purposes the two need not be distinguished. Ordinarily it is distinctly better than other species of the red oak group.

METHODS OF PROPAGATION.

The red oak reproduces freely both by acorns and by stump sprouts. The acorns require two years to reach maturity. They are quite bitter and are not relished by squirrels, and hence can be planted in the field with less risk than white oak acorns.

To secure vigorous sprouts, the trees should be felled between November and March; the stumps should be cut low and left smooth and slanting on top. Sprouts then start close to the ground, where they can soon develop root systems of their own and become self-supporting. The slanting stump causes the rain water to run off, and thus helps to prevent rapid decay.

Red oak develops a taproot, which, in loose soil, grows strong and penetrates to a considerable depth, but in shallow soil may be replaced by strong secondary roots.

PLANTING.

It is usually advisable to plant acorns in their permanent place in the field, for like all oaks, the red oak is not easy to transplant when once fairly established, because of its stout taproot.

Where the area to be seeded can not be plowed, the acorns should be planted in holes about 4 feet apart each way, although the proper distance will depend upon local conditions. Three or four acorns should be placed in each hole and covered with about $1\frac{1}{2}$ inches of earth. If the planting is done on plow land, the soil may be prepared as for any field crop.

Red oak can be grown in pure stands, but it will often do well with other oaks, sugar maple, white elm, chestnut, white pine, and hickories. With chestnut and hickories, red oak needs to be given a start of two or three years, so that it will not be overtopped; but other oaks, elm, sugar maple, and white pine may be planted at the same time. Fast-growing trees, like locust, should not be planted with red oak, unless they are certain to be cut back whenever their branches interfere with the latter.

Plantations of red oak need very little care, except where the rainfall is so deficient that the soil must be cultivated to conserve the moisture. All that is ordinarily necessary is to see that the little trees are not smothered by grass and weeds, that stock and fire are kept out, and that the plantation acquires the character of a forest as soon as it can. Weeds and litter on the ground and shrubs that stand below the crowns of the trees, are good and should not be interfered with.

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FOREST PLANTING LEAFLET NO. 6.

EUCALYPTS.

Several species of eucalypts are suitable for planting in the warmer parts of the United States, but the qualities of the most important are so much the same that only their differences need be referred to. Blue gum is the most extensively planted, and may therefore represent the type.

BLUE GUM (*Eucalyptus globulus*).

FORM AND SIZE.

The blue gum is an evergreen tree, with smooth, elongated leaves of leathery texture and usually sickle-shaped. Under favorable conditions it grows very rapidly and may attain a height of 150 feet and a diameter of from 3 to 5 feet in thirty years. The form is always slender, though, like most other trees, its crown spreads moderately when given plenty of room. In close stands the stems rapidly clear themselves of branches to a considerable height, but they are rarely straight.

RANGE.

The blue gum is not native to the United States, but was introduced from Australia. It has been widely planted in central and southern California, and to some extent in New Mexico and Arizona. Its range is limited by the fact that the young trees can not withstand a lower temperature than 25° F., and it is useless to plant the trees where greater cold occurs. The directions here given are therefore applicable only to limited regions. In California the trees are confined mainly to the citrus fruit belts, although in places the planting range has been successfully extended beyond those limits.

SILVICAL QUALITIES.

Blue gum can adapt itself to many kinds of soil, even that containing considerable alkali, but it is entirely dependent upon a plentiful supply of moisture about its roots. Without that, it grows slowly and does not sprout readily. The soil best suited to it is a deep, sandy loam, with ground water within 10 or 15 feet of the surface. In many localities the lack of water is supplied by irrigation, but as a rule irrigated land is too valuable for commercial plantations. Atmospheric

moisture is not at all necessary; on the contrary the tree grows fastest with its roots close to water and its crown exposed to the sun and wind.

Blue gum develops a strong taproot and a vigorous secondary root system, both of which are capable of penetrating to considerable depths in search of moisture.

The tree is extremely intolerant of shade. Its seedlings thrive for a time beneath the old trees, but if the cover is at all dense they make only a slow growth. This indicates the need of so managing a grove that each individual has its crown entirely free.

It is practically free from injurious insects and fungi. Damage from wind is to be feared only on very shallow soil.

ECONOMIC USES.

The wood is very heavy, hard, strong, and tough, but not durable. It is easy to split when first felled, but not after it has dried. It resembles hickory in many of its qualities, but is extremely difficult to season. The trees are sometimes sawed into lumber and used for wagon work and agricultural implements, though for none of these purposes is the wood as good as that of several native species. It is coming into use for piles in sea water, and it appears to be quite valuable for that purpose, though the trials are not yet conclusive. Its chief value at present is as firewood, for which it is in constant demand in parts of California where other good fuel is scarce. This recommends it for commercial plantations. Another important use of the tree is for windbreaks to protect orange and lemon orchards from the high winds that are prevalent in many parts of the fruit-growing section. No other tree will make so good a shelterbelt in so short a time as blue gum.

METHODS OF PROPAGATION.

The blue gum reproduces freely both by seeds and by stump sprouts. Plantations must be established with seedlings, but the vigor of the sprouts recommends that means of renewing a grove when it is cut.

The seeds are produced in large quantities every year. Most of them ripen in the fall, usually just before the rains. The fruit should be gathered before the valves open, and spread on sheets in the sun. In a few days the seeds will be freed and may be easily separated from the hulls and chaff. They should be planted at once in shallow boxes filled with not less than 3 or 4 inches of sandy loam, or in small paper or bamboo pots. The box most commonly used is 18 by 30 inches and 3 inches deep. It is better to plant the seed in this way than in seed beds, because the boxes or pots make it possible to transport the young plants to the planting ground without taking them from the soil. The seedlings are very tender and may easily be injured by exposure of their roots to the dry air. The use of boxes also serves to keep the young trees from developing taproots so long that they can not easily be transplanted. Two or three seeds should be sown in each pot, or in groups

about 2 inches apart in the boxes, and covered with about one-quarter inch of sand. The boxes should be kept moist until the seeds germinate, which they usually do in about ten days. After that time they may be set outdoors and the plants left to be watered by the rains, or they can be housed and watered artificially. In either case the plants should be watched, lest they become too wet and suffer by the fungous disease called "damping off." Where the seedlings come up thickly, it is a good plan to take from each pot or group all but the one strongest plant, and to transfer the rest to other boxes. This should be done when the plants are about 2 inches high.

PLANTING.

Towards the end of the rainy season, or about the first of March, the seedlings will be about 6 inches high, and may then be taken to the permanent site and planted out. If grown in pots, the whole thing may be set in the ground, and the paper or bamboo left to rot. If boxes are used, each plant should be removed from the soil and set at once in ground previously prepared with plow and harrow. If the ground is dry, it will be necessary to water each young tree as soon as it is set out, and perhaps to continue watering for a year or two, but the trees should gradually be accustomed to do without irrigation. The planting of eucalypts for commercial purposes is not advised where the trees can not find their own water within two years.

For woodlots a good spacing is 8 feet by 8 feet. This gives room to cultivate the young trees, yet sets them close enough to grow tall and clear. The plantation should be cultivated frequently for two years; at the end of that time it should be able to take care of itself.

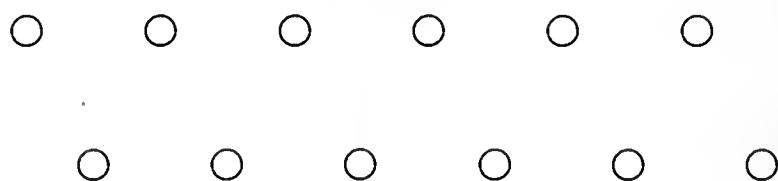
This method of propagation is recommended because it takes advantage of the rainy season to grow the seedlings and get them established before the air becomes very dry. Some growers do not plant the seeds until spring, and a few sow the seeds in the permanent site or collect wild seedlings from an old grove. Any of these methods may be followed, though the first described is apt to be the surest and best. Those who contemplate planting will naturally compare the cost of seedlings from a nursery with the cost of those they may raise.

WINDBREAKS.

It is decidedly unfortunate that blue gum can not be planted more widely for windbreaks. If set out with an orchard, the windbreak will easily keep ahead of the fruit trees; in most cases it will attain a height of 50 feet or more in six years, and of 100 feet in ten years. The great value of blue gum for windbreaks lies in the facts that it grows very tall without taking up much ground, that it is firm against all winds but tornadoes, and that its crown is flexible and elastic, and, by bend-

ing, diverts the wind diagonally upward, instead of offering a resistance that forces it to go through in strong currents. On the other hand, there is the disadvantage that the clear trunks offer little opposition to the wind near the ground. This, however, is easily overcome by planting a close row of cedar or cypress next to the gum.

Blue gum windbreaks are most effective when composed of two rows of trees set 4 feet apart in the following manner:



Many planters, however, are satisfied with a single row.

The intervals between parallel windbreaks will vary according to the character of the local winds, but in most parts of California it is thought best to have them not more than 400 feet apart. The trees may be obtained, planted, and cared for in the same way as those in woodlots.

Either Monterey cypress or Italian cypress is recommended for the lower part of a composite windbreak. Both grow quite rapidly and will maintain a dense hedge to a height of from 30 to 40 feet. One row of blue gum and one row of cypress are all that is necessary. The latter may take the place of the leeward row of blue gums indicated in the diagram above, though when the cypress trees are about 10 feet high, every other one should be removed, leaving them 8 feet apart. The blue gums should be maintained with their original spacing of 4 feet, by planting a new tree wherever one dies.

FIRE.

Every eucalyptus plantation must be carefully guarded from fire. The fallen leaves, twigs, and bark shreds, which always cover the ground to a considerable depth, are naturally oily, and in the dry air of the Southwest become highly inflammable. If a fire once starts it is almost impossible to put it out before the heat, if not the direct flame, has killed or seriously injured the trees. The bark of the trees is not thick, and affords little protection to the living tissue.

CUTTING.

Since it is always advisable to reproduce a eucalyptus grove by means of stump sprouts, care should be taken that the trees are felled between November and April, and that the stumps are cut low, smooth, and slanting on top. When the cutting is done at the right time the sprouts are vigorous and have time to harden, while the roots are not exhausted. The stumps should be low, in order that the new shoots may be forced to start close to the ground and establish their own roots as soon as possible, and smooth and slanting, so that rain water may not gather on them and hasten decay. When the shoots reach a diameter of about

2 inches, all but three or four of the straightest, most vigorous, and best placed ones should be cut out from each cluster. This thinning should yield enough firewood to pay for the cost, but whether it does or not, it should not be omitted, for it will cause the remaining shoots to grow much faster by giving them more light and room.

COST OF AND RETURNS FROM PLANTATIONS.

Windbreaks are usually made without much reference to their cost, for they are often indispensable. Woodlots, on the other hand, should pay at least as much, either directly or indirectly, as the land they occupy would yield in any other crop.

The cost of establishing a plantation of blue gum will depend largely upon local wages. The cost of maintaining it when once established depends entirely on the rental value of the ground. The following figures may be accepted as the average cost of establishment for an acre in most localities. All expenses, with compound interest at 5 per cent, are carried to the time when the plantation is 12 years old and yields its first crop.

Preparation of soil.....	\$7.00
700 plants, at \$8 per thousand.....	5.60
Planting.....	4.00
Cultivating 5 times, first year.....	2.50
	<hr/>
	19.10
Interest on \$19.10 for 12 years.....	15.20
Cultivating 3 times, second year.....	1.50
Interest on \$1.50 for 11 years.....	1.06
	<hr/>
Total cost, excluding land rent, at end of 12 years.....	36.86

Disregarding the small possible yield from thinnings before the main crop is mature, the wood that can be cut at the end of twelve years will probably amount to 60 cords. This will bring \$3 per cord on the stump, or a gross income of \$180.

The net income at the end of twelve years is what remains after deducting the gross cost of the plantation exclusive of rent, \$36.86, from the gross income, \$180, or \$143.14, which is equivalent to an annual net income of \$9 with interest at 5 per cent. If the rental value of the land is \$5, the annual net profit would be \$4; if the rental value is \$6, the profit is \$3, and so on.

After the first crop, the returns will be greater, because planting and cultivation will be saved and the trees will be large enough to cut again in eight years. For the second and succeeding crops, the yield will be 60 cords of wood at \$3 per cord, or \$180, which, since there is no expense, is the net income from 1 acre for eight years, equivalent to an annual net income of \$18.85. Again assuming a land rental of \$5, there remains a net profit of \$13.85 per acre per year.

RED GUM (*Eucalyptus rostrata*).

This species does not grow so rapidly as blue gum, but in most other respects is superior to it. Comparatively few plantations have so far been made in the United States, but those that are established give promise of quite as good returns as any of blue gum. The tree is more hardy than the blue gum, and will withstand more alkali and more drought than the latter. When young, it is nearly as susceptible to frost as the blue gum, but mature trees may survive as low temperatures as 15° F.

The wood is heavy and hard like that of blue gum, but is red in color and much more durable. This last quality apparently makes it available for posts, poles, and piles, and goes far to recommend it in preference to blue gum. Plantations may be made in the same way as those of the commoner species, and at about the same cost. Planters are recommended to give this tree a trial, especially where there is a demand for other material than firewood.

SUGAR GUM (*Eucalyptus corynocalyx*).

The chief value of this species is that it endures more drought than either of the others described. In most of its qualities it is similar to red gum, and under good conditions grows nearly as rapidly.

The wood is heavy, not so hard as blue gum, easy to split, makes a very hot fire, and is moderately durable. It is also said to season better and to work more easily than the wood of other eucalypts.

The tree may be propagated in the same way as blue gum, and is recommended for planting because of its good qualities, among which is its ability to grow in localities where the heat and drought are too severe for other species.



United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 7.

RED PINE (*Pinus resinosa*).

FORM AND SIZE.

The red, or Norway, pine generally attains a height of between 70 and 90 feet, and a diameter of 2 or rarely 3 feet. When grown in the open, the tree is relatively short, and branched close to the ground. In the forest the stem is commonly clear for 40 to 60 feet, and the crown is short and open, but broad-spreading.

The distinguishing features of red pine are its thin, scaly, reddish-brown bark, and its slender and flexible leaves 5 to 6 inches long in clusters of two.

RANGE.

The natural range of the red pine is along the northern border of the United States as far west as Minnesota, and southward through the Northern States to eastern Massachusetts, the mountains of Pennsylvania and northeastern Ohio. It reaches its best development in the northern portion of Michigan, Wisconsin, and Minnesota.

The red pine is adapted for planting throughout most of the northeastern part of the United States. It will not do well where droughts are frequent or severe.

SILVICAL QUALITIES.

The red pine grows best on sandy loam soil, well drained and of moderate fertility, but it also thrives on poor sands when other conditions are favorable. The tree is very intolerant of shade at all ages and therefore suitable for pure plantations only, or for mixtures in which the other species are distinctly slower growing. Its rate of growth is fairly rapid. Measurements made in several New England plantations show an average height of 35 feet and diameter of 6 inches at 30 years of age.

Red pine suffers little from insects or disease. It is moderately fire-resistant and quite free from destructive fungi. When young, the tree is sometimes injured by a white grub which feeds on the tender roots, but the mature tree has few enemies.

ECONOMIC USES.

The wood is somewhat like white pine, though a little heavier, harder, and stronger. It is only moderately durable. It is distinctly valuable for all kinds of house lumber, and when chemically treated makes good posts and ties. In most of its qualities it compares with the shortleaf pine of the South, and with western yellow pine.

PROPAGATION.

Red pine grows only from seed. While the trees do not produce large quantities of seed, and seed years occur at intervals of from two to four years, there is usually a sufficient natural reproduction wherever there are old trees.

The seeds ripen in the fall of the second year after the flowers appear, and may then be gathered and kept over winter in any cool, dry place.

The seeds should be planted in the spring in well-prepared beds, either in drills about 5 inches apart extending across the beds, or broadcast, and covered lightly with earth well pulverized and pressed down firmly. When the seedlings are two years old they may be transplanted to nursery rows, or set in their permanent places in the plantation.

It is desirable to keep the nursery beds moderately moist, for if too dry the plants will either die or send their roots so deep in search of water that they will be difficult to transplant.

One pound of seed contains about 75,000 grains, and, under average conditions, will plant about 400 lineal feet in drills, or 100 square feet broadcast.

The young seedling develops a strong taproot, but later produces several stout laterals which firmly anchor the mature tree, unless the soil be very shallow.

PLANTING.

For planting red pine it is best to use seedlings two or three years old which have been raised in nursery beds.

The young trees should be set out in the spring, late in April or early in May. They may be planted in furrows or in holes made with a spade, mattock, or planting bar. As a rule, the proper spacing is 4 feet each way, although this will vary in different localities.

It is usually advisable to plant red pine pure, though on good soil sugar maple, beech, or elm might be mixed with it. Any associate must be of slower growth than the red pine, or the latter will be overtopped and suppressed. Mixture with white pine has generally proved satisfactory.

CULTIVATION AND CARE.

If red pine is planted on cut-over lands, more rapid-growing species such as jack pine, aspen, and birch must be prevented from choking it

out. No cultivation is needed, and the protection necessary is from fire and grazing.

The red pine, being intolerant of shade, very readily clears itself of its lower branches when close-grown, and never requires pruning.

EXAMPLES.

Several plantations of red pine have been made in New England, where this species makes more rapid growth than the planted white pine, since it is unaffected by the prevalent white pine weevil.

A most instructive example of a successful red pine plantation is found near Lake Winnepesaukee, New Hampshire, where it was planted pure and also in mixture with white pine, about thirty years ago. Measurements made in a twenty-seven-year-old stand of these two species show that the red pine has an average height of 34.9 feet and is taller than the white pine.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 8.

HOW TO TRANSPLANT FOREST TREES.

The tree planter should endeavor always to transplant his trees with the least exposure of their roots. The root-hairs, or feeding cells, on the roots of a plant will shrivel up and perish if exposed to the dry atmosphere for even a few minutes. The roots of conifers are particularly sensitive, so that these require more careful attention in transplanting than do broadleaf trees. Some of the broadleaf species may have their roots dried out and shriveled, yet with proper attention revive and live; but the conifers, once dried, rarely regain their vitality.

THE PROPER SEASON.

The best time to transplant young trees is just before growth begins in the spring, when the seedlings are likely to receive the least injury. In general, planting should be done as soon as possible after the frost is out of the ground, the exact period depending upon local climate and soil conditions. In parts of the country where the winter is the only season with an abundant rainfall, the transplanting should be done during the rainy season.

Fall transplanting in the prairie States is usually unsatisfactory, since the dry, freezing weather of winter often damages the young shoots. In the States east of the Mississippi, fall planting is more successful, though small seedlings are often likely to be heaved out by the frost, if not protected by mulching.

Conifers, with the exception of the deciduous species, such as European larch and tamarack, may be safely planted somewhat later in the season than broadleaf trees.

It is always well to choose a wet or cloudy day for transplanting, but if the work must be done in dry weather, the nursery beds or trenches should be thoroughly soaked a few days before removing the trees. By establishing a home nursery, close to the planting site, the disadvantages of shipment may be avoided, some expense may be saved, and the time for planting may be considerably extended. The last point is often of importance, because it may be inconvenient to drop other work in order to give a shipment of trees the immediate attention they require. Home-grown stock may be left in the nursery until a favorable opportunity for getting out the trees occurs.

TREATMENT BEFORE TRANSPLANTING.

As a rule, seedlings from one to three years old are the best for forest plantations, and those of most species require no preliminary preparation. Older trees, however, and certain conifers like Coulter pine, western yellow pine, longleaf pine, and such broadleaf trees as form long taproots, should have their roots pruned in the seedbeds. This may be done late in the summer by running a "tree digger" under each row of trees and allowing the plants to stand undisturbed for another season, or, with small seedlings, the roots may be pruned with a sharp, flat spade or a special implement designed for the purpose.

European foresters move young trees with balls of earth adhering to their roots, such trees being called "ball plants." Where the eucalyptus is cultivated on a large scale, the seedlings are frequently prepared for easy transplanting by being grown in small pots made of bamboo or other cheap material. The pots are planted with the trees.

When the trees to be moved are large, they are often prepared by digging them partly out in the fall, so that a large ball of earth may be frozen to their roots. The chunk of frozen soil, with the tree in it, is moved during the winter season to a hole which was dug before the ground became frozen.

PUDDLING.

When a seedling or transplant is taken from the ground, its roots should immediately be plunged into a vessel containing a mixture of earth and water about as thick as cream. This mixture is known as "puddle," and is one of the most important requisites for successful tree planting.

The puddle may be prepared in a pail, tub, or barrel, according to the size and number of the trees to be transplanted, and may be carried or drawn along the rows where the digging is in progress. If the trees are to be planted immediately, the vessel holding the puddle may be used as a receptacle to carry them from the nursery to the planting sites.

HEELING IN.

If seedlings are received from a distance, the trees should be unpacked at once, and their roots should be dipped into a puddle. After this, the trees should be "heeled in," according to the following method, and left for planting in the field:

Dig a trench deep enough to bury the roots and part of the stems. The trench should run east and west, with its south bank at a slope of about 30 degrees to the surface of the ground. A layer of trees should be placed in the trench on its sloping side, the tops toward the south. The roots and stems should be covered with fresh earth dug from the second trench, in which a second layer of trees is put and covered in the

same way. The digging of the parallel trenches is repeated and layers of trees are put in, until all have been heeled in. (See fig. 1.)

In the case of conifers, care should be taken not to bury the foliage, and either to choose a shady place for the young trees or to construct a shade over them with bush or laths.

TRANSPLANTING IN NURSERIES.

With most species, especially with conifers, where seeds are planted in beds, it is necessary to transplant a portion of the young seedlings to nursery rows when they are one or two years old. This stimulates the growth of small roots, makes the plants much more vigorous than others of the same age not transplanted, and helps them to establish themselves better when permanently set out.

When the seedlings are dug from the seedbed they should be dipped in a puddle and immediately be set in the nursery rows, or, if delay is necessary, they should be laid, roots together, in piles of a hundred or more, and the roots should be covered with wet blankets or with a few shovelfuls of fresh earth.

In ordinary nurseries which are to be cultivated by hand, the rows for conifers should be 1 foot apart

and those for broadleaf trees 2 feet apart. Coniferous seedlings should be set 4 inches apart in the row and broadleaf seedlings about 6 inches apart. All plants should be set from 1 to 2 inches deeper in the rows than they grew in the seedbed. If the seedbeds are not wanted for another planting, the seedlings to be transplanted may be taken out in such a way that thrifty plants will be left with the same intervals as in the nursery rows. They should then be cared for the same as transplants.

Some trees, like the oaks, the walnut, and the catalpa, form long, fleshy taproots during the first season, with few lateral roots. This form of root is sometimes very troublesome to transplant. Before setting such plants in the nursery rows from one-fourth to one-third of the taproots should be cut off. A bundle of a hundred or more plants may be laid across a log and their taproots cut off with a sharp axe. Care must be taken not to bruise the part of the root that is left. Seedlings with a bunch of short, fibrous roots need no cutting.

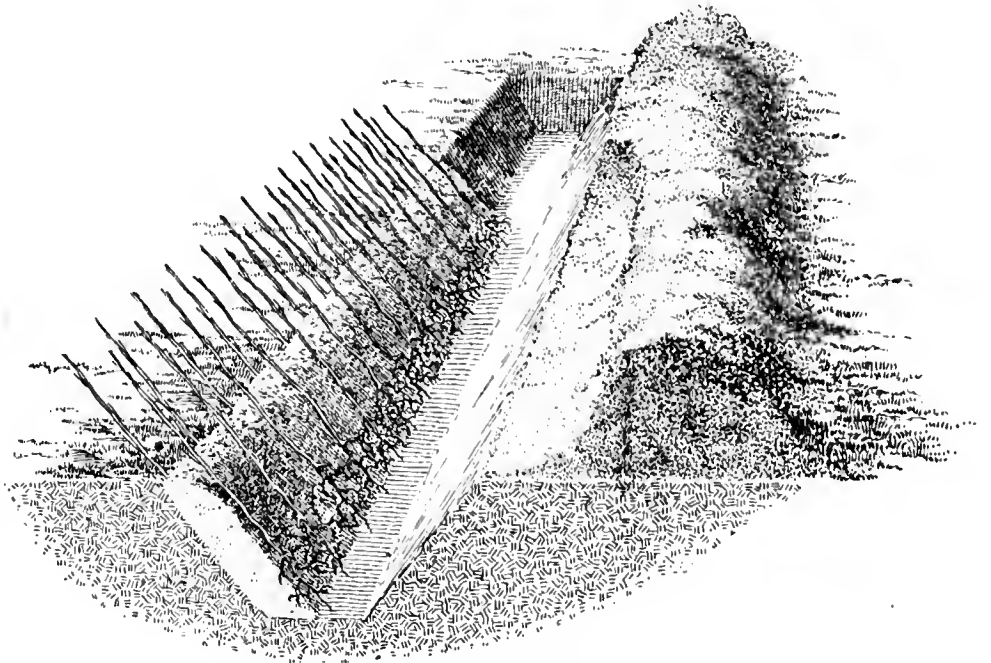


FIG. 1.—Heeling in young trees.

Following the transplanting of seedlings the nursery rows should be kept clear of weeds and the soil stirred frequently with hoe or cultivator. It is especially necessary that the nursery be gone over after a rain as soon as the surface soil is dried out sufficiently to work well. This will prevent the deeper moisture from drying out about the roots of the trees. In case no rain falls within two weeks after the plants have been set in the nursery, water should be applied to the rows. In dry regions frequent shallow cultivation to maintain a dust mulch should be given.

TRANSPLANTING FROM NURSERY TO FIELD.

On the plains and prairies, the land, provided it has not been in a cultivated crop the preceding season, should be plowed deeply in the fall previous to planting and left rough over winter. In the spring it should be worked to a mellow condition and marked for planting in check rows, or listed if the trees are to be planted in furrows. In the East, and on non-arable ground, this preliminary preparation may be dispensed with.

In transplanting seedlings from the nursery to their permanent place in the field, the same care should be taken to prevent the exposure of their roots to the air as when transplanting them to the nursery rows. Where trees are to be transported but a short distance, balls of earth about their roots, which are a necessary safeguard for long distances, are a good protection, but expensive. When a large number are planted, the trees may be carried, roots downward, in a pail containing several inches of water.

The seedlings may be planted either in furrows or in holes dug with a mattock or spade. A good plan is to drive a narrow spade straight into the soil and then form a cleft by working the handle back and forth. In this cleft a tree is planted, its roots are straightened out, and the hole is filled with earth. The ground around the newly planted tree should always be packed firmly so as to fill up all air spaces and bring the earth in close contact with the roots. It should not be so hardened as to be impervious to water. In dry regions it is always desirable to leave a depression a few inches deep around the collar of the plant, in order to collect any moisture that may fall. Another plan, where stones are available, is to pile a few loose stones around the base of each plant. These prevent the rapid evaporation of moisture from the soil around the roots.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 9.

SHAGBARK HICKORY (*Hicoria ovata*).

FORM AND SIZE.

The shagbark hickory is a forest tree which commonly attains a height of 70 to 80 feet and a diameter of about 2 feet. Under favorable conditions, a height of 120 feet and a diameter of 4 feet is reached. When grown free the stem often branches near the base and the crown becomes full, though it always remains narrow; in the forest, the crown is short and small, while the stem frequently has a clear length of from 50 to 60 feet.

The characteristic feature of the shagbark hickory, from which it gets its name, first appears in the older trees in the long, loose plates or strips of bark which are produced on the trunks. On young trees the bark is very smooth and close.

RANGE.

The natural range of shagbark hickory is from southern Maine west through southern Michigan to eastern Kansas, Nebraska, and Texas, and south along the Appalachian Mountains to Florida, Alabama, and Mississippi. It reaches its best development on the western slopes of the Appalachians and in the regions drained by the tributaries of the Ohio River.

The shagbark hickory is generally found in mixture with other trees, although pure stands are not rare. Its principal associates, besides other hickories, are the oaks, maples, and ashes, chestnut, basswood, and yellow poplar.

The tree is recommended for planting on good soil in the valley of the Ohio River and along its tributaries in Ohio, Indiana, Illinois, Kentucky, and Tennessee, and on fertile hillsides of the Appalachian Mountains.

SILVICAL QUALITIES.

Shagbark hickory grows best in a deep, rich, moist loam. It does well in other moderately rich soils which permit the taproot to penetrate to a moist subsoil, and in the Middle States makes good growth

in comparatively well-drained situations wherever it can get the requisite amount of sunlight. It will not thrive in a hard clay soil, or in pure sand, or where a layer of hardpan lies near the surface.

It is intolerant of shade, and does well only in the open or when surrounded by other trees which only slightly obstruct the light. When overshadowed, it grows very slowly. Under right conditions the rate of growth is fairly rapid, comparing favorably with that of white oak.

The tree is subject to the attacks of fungi, which do considerable damage to the leaves and twigs, and numerous insects feed upon it. In recent years, a large number of trees have been attacked by the hickory bark beetle, which in some sections has killed nearly all of them. The tree is valuable enough, however, to be worth planting in spite of these dangers.

ECONOMIC USES.

The wood is heavy, hard, very strong, tough, flexible, but not durable in contact with the soil. It is used extensively in the manufacture of carriages and agricultural implements, and for ax and tool handles. There is, in consequence, a good demand for the lumber, at a high price. Second-growth hickory, or that which is largely sapwood, is especially esteemed. The wood of the young sprouts is used in making baskets, barrel hoops, and other articles in which flexibility and toughness are required. The wood is also valuable for fuel.

PROPAGATION.

Shagbark hickory reproduces itself both from seeds and from sprouts. Natural reproduction by seed, however, is seldom good, because a large percentage of the nuts is eaten by squirrels, or in mixed stands in the forest the light-loving seedlings are suppressed by other species.

Sprouts from young hickory stumps grow rapidly, and the sprout method of reproduction is advised where an existing plantation or a natural grove of small trees is to be renewed. If good trees are to be produced from stump sprouts, the stumps should be cut low and left smooth and slanting on top. The low stump compels the shoots to start close to the ground, where they can soon form a root system of their own and become self-supporting; while the slant causes rain to run off, and thus prevents decay. All but two or three of the best sprouts should be removed from each stump at the end of the first season. The sprout method is particularly well adapted to the production of small-sized material for hoop-poles and carriage stock.

PLANTING.

On account of the strong taproot which shagbark hickory develops, the cultivation of seedlings in a nursery is advisable only where nuts planted in the field are sure to be destroyed by mice or squirrels. The

best plan is to gather the nuts in the fall, keep them over winter between layers of sand, and plant them in the spring where the trees are to stand permanently. If the nuts are properly handled and not disturbed, from 50 to 75 per cent of them will germinate, but, since rodents are always to be feared, it is well to plant two or three nuts in each hole. They should be planted about 2 inches deep. The growth of the seedlings during the first season should be from 6 to 9 inches.

The spacing will depend upon the object of the plantation; if nuts are the object chiefly desired, wide spacing (about 20 feet by 20 feet) is essential, whereas for a woodlot about 6 feet by 6 feet is right.

Shagbark hickory does well when planted in pure stands, but if the plantation is to be allowed to grow to a considerable age, some other slow-growing species may be mixed with it, or, after it has attained a good growth, it may be planted with a species tolerant of shade. Hemlock and sugar maple are good trees for this purpose.

CARE AFTER PLANTING.

If the plantation is on tillable land, it should be carefully cultivated until the trees become large enough to shade the ground. In any case livestock of all kinds should be excluded, and protection against fire should be provided for. If the plantation is attacked by the hickory bark beetle, the infested trees should be cut and the bark should be burned before the middle of May, or advice should be asked of the Bureau of Entomology, U. S. Department of Agriculture.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 10.

BASSWOOD (*Tilia americana*).

FORM AND SIZE.

The basswood is a forest tree which often attains a height of 70 to 80 feet, and a diameter of 2 feet. Under favorable conditions it may be considerably larger. When grown free the tree bears a large, compact crown, which makes a dense shade; in the forest it has a straight stem with but few branches, which are closely clustered at the top. The inner bark (bast), from which the tree gets its name, is fibrous and tough.

RANGE.

The natural range of the basswood is from New Brunswick south along the Allegheny Mountains to Alabama, and westward to eastern Texas, Nebraska, and southern Minnesota. The tree is commonest about the Great Lakes but attains its best development on the bottom lands of the Ohio River, where it is associated with white oak, cottonwood, white ash, black walnut, and hickories. It may be planted on good soils almost anywhere within its natural range; though the most favorable region for economic planting is within the Northeastern States and north of the Ohio River.

SILVICAL QUALITIES.

The basswood is best suited to deep, rich, river bottom soils, and to cool situations. While it will maintain itself on poorer uplands, it is recommended for planting only where the soil is moist and well drained and where droughts are infrequent. It is, in general, a hardy tree. It is moderately tolerant of shade, and the seedlings require some protection from the hot sun. In dry situations it is subject to injury from the sun's heat.

The rate of growth is fairly rapid during early age, being about the same as that of red oak and Norway maple. After attaining maturity the trunk frequently becomes hollow.

The basswood is sometimes attacked by insects, which denude it of leaves or bore into the bark, but serious damage is not frequent. The European species are much more liable to insect injury than the native basswood, and are much less desirable trees generally.

ECONOMIC USES.

The light brown wood is soft, straight-grained, and easily worked, but not durable. It is often sold under the name of whitewood, and is largely used for house lumber, woodenware, carriage bodies, panel work, trunks, and paper pulp.

Its large crown and dense foliage render it desirable for planting along roadsides and about the home, and also for low shelterbelts throughout the greater part of its range. Its flowers, which yield great quantities of fine honey, lend it great value for bee keepers.

PROPAGATION.

The basswood reproduces freely both by seed and by sprout. The seed ripen in September or early October, and may easily be collected while attached to their large wings or bracts. They should be separated from the wings and planted at once in nursery beds, as alternate freezing and thawing during the winter rots and loosens the seed coat and causes early germination. If it is impracticable to plant in the fall, they may be kept over winter in a cool, dry place between layers of sand.

The basswood is one of the most prolific among our native trees in sprouts from the stumps, and hence this method of renewing an old stand is recommended. To secure vigorous sprouts the trees should be felled between November and March, and the stumps cut low. Sprouts then start close to the ground, where they can soon develop a root system of their own and become self-supporting. All but two or three of the sprouts should be removed at the end of the first season. Under favorable conditions a sprout grows only about a foot the first year.

The basswood seedling develops a single stout root, but this is soon replaced by a number of lateral roots which give the tree a strong hold upon the ground.

PLANTING.

In planting the basswood it is best to use one-year-old seedlings, which should be set out as soon as the frost is out of the ground and before the leaves unfold. As a rule it is advisable to space the trees about 5 feet apart each way.

Basswood does well when planted in pure stands, but it is also of value in mixture with white or red pine (on good soil), or with white elm, white oak, red oak, maple, or hickories.

CARE AFTER PLANTING.

In most situations to which basswood is adapted, little cultivation is needed, since the heavy crowns and rapid growth of the young trees will soon form dense cover, which will exclude grass and weeds and furnish the proper soil conditions. Where the undergrowth is very rank, however, it is necessary to clear out the weeds, in order to give the trees growing space.

Cattle have an especial fondness for basswood boughs and foliage, so that the young trees must be carefully protected from them.

The plantation should be carefully guarded from fire, and should be allowed to assume the character of a forest as soon as it can.

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United States Department of Agriculture,
FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 11.

BLACK LOCUST (*Robinia pseudacacia*).

FORM AND SIZE.

The black locust (known also as "yellow locust" or often simply "locust") is a forest tree which usually attains a height of from 40 to 60 feet, with a diameter of from 1 to 1½ feet. Under the most favorable conditions it may reach a height of 80 feet and a diameter of 3 feet. In the forest the tree has a clear, straight stem and a small crown. In the open or when grown in plantations the stem tends to divide early, and a more spreading and longer crown is formed. Individual trees, especially when grown in the open, are liable to be bent or twisted by storms.

RANGE.

The natural range of the locust is throughout the Appalachian Mountains from Pennsylvania to Georgia and in certain portions of eastern Indian Territory and Arkansas. It reaches its finest development on the western slopes of the Appalachians in West Virginia.

The locust is found in mixture with other trees of the forest or in pure stands on forest land that has been burned over. On slopes its principal associates are black, red, and chestnut oaks, chestnut, pignut hickory, and maple. Along streams it occurs with ash, maple, black walnut, and other species.

Theoretically, the range for planting is extensive, covering the region between the Atlantic Ocean and the Mississippi River and extending west of the Mississippi River south of the thirty-eighth parallel as far as the Rocky Mountains. It is also adapted to the valleys of Utah, Idaho, and eastern Oregon and Washington when planted on irrigated land. The forest plantations to be seen near Salt Lake City, Utah, and Walla Walla, Wash., are among the best in the United States. Recent investigations indicate that the locust can be grown with success in portions of California. Its actual range for economic planting, however, is greatly restricted by the danger of insect injuries.

HABITS AND GROWTH.

The locust grows best on a deep, well-drained, fertile loam, but will grow on almost any soil except a wet, heavy one. It attains an excellent development on limestone formations.

Locust is very intolerant and requires an abundance of light during

its entire life. When overshadowed it declines very quickly. In its native home it is found along streams, on the borders of the forest, or singly and in groups on the steep slopes.

Locust is a rapid-growing tree, but is relatively short lived. In good situations it makes an average annual height growth of 2 to 4 feet and a diameter growth of one-quarter to one-half inch. This rate is sometimes maintained for twenty-five or thirty years, but more frequently the growth becomes slower between the fifteenth and twentieth years. After the fiftieth year growth almost entirely ceases.

THE LOCUST BORER.

The value of the locust is practically destroyed in many parts of the United States by the locust borer, which riddles the trunk and branches. The attack may commence when the trees are quite small, and where the borers are numerous the plantation is killed outright within a short time. In localities where the attacks of this insect are slight it is sometimes possible to grow the trees to fence-post size before the plantation is seriously affected. Plantations of locust in Oklahoma, Indian Territory, and in the States west of the Rocky Mountains are almost entirely free from injury by this insect. In most of the States east of the Rocky Mountains planting is restricted or made impossible, according to the local severity of damage by the borer. In case this insect or others seriously injure a forest plantation of locust, the Bureau of Entomology of the Department of Agriculture should be consulted at once.

ECONOMIC USES.

The timber of the locust is extensively used for fence posts, ribs of vessels, treenails, insulator shanks, and vehicles. Its great durability in contact with the soil makes it very valuable for use in the ground, and its toughness and elasticity give it value where great strength is required. The tree is also valuable for fuel, being about equal to bur and white oak for this purpose.

The most common use of locust is for fence posts, for which purpose it has been extensively grown. Because of the large proportion of heartwood the young wood is almost as durable in the soil as the old. Locust posts, under average conditions, will last from fifteen to twenty-five years.

METHODS OF PROPAGATION.

Locust reproduces itself abundantly by seeds and by stump and root sprouts. It extends itself rapidly over old fields and along fence rows. Burned and cut-over lands in the mountains of Pennsylvania and West Virginia are thickly covered with locust seedlings, frequently giving rise to valuable pure stands of this species. The seed is retained on the trees well into the winter and distributed long distances by the strong winter winds. Wherever locust has been planted outside of its natural

range the same tendency to spread by seed and root sprouts is exhibited, and young stands killed by fire replace themselves at once by sprouts.

PLANTING.

The seed may be gathered locally by the individual planter or may be purchased from dealers. It may be left in the pods and stored in a cool, dry place for as long as two years without serious harm. If the seeds are removed from the pods, they should be stratified in moist sand in a cool place. Just before planting, the seeds should be soaked for four or five days in water that has been heated to a temperature of 150° to 160° F., which will cause them to swell. Planting should immediately follow the soaking of the seeds, as under no consideration should they be allowed to dry out. The percentage of germination under these conditions is about 50 to 75 per cent.

Spring planting is in general advisable, although the seed can be sown as soon as it matures. The soil of the nursery should be well pulverized, rich, and loamy. If hand cultivation is to be given, the drills may be 12 to 15 inches apart, but if horse cultivation is to be practiced, rows 2 to 3½ feet apart will give the best results. The seed should not be covered to a greater depth than one-half inch, and the soil should be kept uniformly moist during germination. A pound contains about 29,000 seeds and is sufficient for a row 900 feet long. The seedlings will be large enough to set out in their permanent sites the following spring after planting the seed in the nursery, and in one year they should have attained a height of 1 to 3 feet.

Since the locust has a wide-spreading root system, it requires plenty of room for the proper development of the tree. A spacing of 4 feet apart each way is too close unless very early thinnings can be made and the material utilized for stakes. In the East the trees should be set at least 6 feet apart each way. In the Middle West they should be spaced 4 feet apart in rows 6 feet from each other or 3 feet apart in rows 8 feet apart.

Locust does well in pure stands, but in the semiarid region of the Middle West, where the forest plantation is valued also for its protective character, it may be mixed with Russian mulberry, Osage orange, or green ash.

CULTIVATION AND CARE.

In the Middle West careful preparation of the soil and cultivation for several years after planting are essential for successful growing of the locust. In order to secure a stem that will make straight posts, poorly formed or double-headed trees may be cut back to the ground or pruned two or three years after planting.

Stock should be entirely excluded from the plantation and every precaution taken to prevent fire from running over the ground.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 12.

NORWAY SPRUCE (*Picea excelsa*).

FORM AND SIZE.

The Norway spruce develops a straight, undivided trunk, with small, slender branches which become somewhat drooping in later life. In the open the limbs, extending almost to the ground, form a well-shaped, conical crown. The forest-grown tree retains its conical form, but the crown is much more compact and is restricted to the upper portions of the trunk.

In size, the Norway spruce is not unlike our red spruce. Trees 80 to 100 feet high and 2 to 3 feet in diameter are common in Europe on good situations.

RANGE.

This species is not indigenous to North America, but is a native of northern Europe and Asia. It is almost invariably confined to cool, somewhat moist situations. In Europe it ranges from the shores of the Baltic and the lower mountain slopes of Scandinavia to the Alps, where it occurs at an altitude of 6,000 feet. Planting has widely extended the limits of its distribution. It was introduced into England in the sixteenth century and in the United States has been grown as an ornamental tree for many years.

The possible planting range in this country is not yet fully known. As a rule it will thrive throughout the entire Northeast and southward at the higher elevations. In the West favorable results have been attained only as far as the eastern part of the prairie region, and then only in the more protected localities. The great field for planting on a large scale is the cut-over land in the North, where the tree serves to provide for a future supply of wood suitable for pulp. It will adapt itself within certain limits to situations similar to those formerly occupied by our spruce forests, and it is in every way a superior tree.

HABITS AND GROWTH.

A rich, deep soil is not demanded by the Norway spruce, although it grows more rapidly on the better soils. The tree will grow well in a fresh, shallow, moderately porous soil, whether fertile or not, and will thrive with moderate moisture. It will not endure drought or a natu-

rally dry soil. In common with our native spruces, this species is very shade enduring, forming dense stands which protect the soil and maintain forest conditions perfectly. The root system is shallow and not extensive.

The growth during the first decade is rather slow, but after this period there is a rapid increase in both height and diameter growth, followed by a gradual lessening. It is much more rapid in growth than our native spruce.

The Norway spruce is not subject to serious damage by insects or fungous diseases, but is seriously injured by drought, hot winds, and late frosts, while its shallow root system renders it liable to be thrown by the wind if exposed.

ECONOMIC USES.

In the United States little use has been made of the Norway spruce. The timber is light, soft, non-resinous, and fairly durable. It works well, splits easily, and seasons without serious warping.

Abroad, its largest uses are for construction timber, fuel, and paper pulp. Its utility for the last purpose should lead to extensive commercial planting in this country. The timber is excellent for general construction purposes as well, and may be used as a substitute for white pine.

Although the species is useful in protection forests, such as shelterbelts and windbreaks, it is not hardy enough for planting in the Middle West, where such forests are most necessary. In the East, however, it may be planted as a protection belt about exposed hardwood groves.

The rapid growth and graceful form of the Norway spruce in open situations has lead to its wide use for shade and ornament.

METHOD OF PROPAGATION.

The Norway spruce is a heavy seeder, bearing a full crop every two or three years. The cones mature in September or October. They should be picked from the trees in the fall, and the seed extracted and stored in a cool, dry place during the winter. If carefully stored the seed can be kept from three to five years without serious loss of vitality.

If there are no cone-bearing trees in the vicinity, seed may be purchased. Samples sent to the Seed Laboratory of the Department of Agriculture will be identified and their germination per cent determined. Of fresh seed, fully 60 to 75 per cent should be fertile.

Home-grown seedlings should be used in the plantation when possible. Seedlings may be purchased, but it is better and cheaper to raise them on the tract. Bulletin 29 of the Bureau of Forestry gives instruction in all phases of nursery practice.

The nursery should be located on fertile, well-drained soil, preferably a sandy loam, and beds should be carefully prepared by working the ground thoroughly. The seed may be sown broadcast or in drills.

Broadcast sowing gives the larger number of seedlings, but drilling is better because the beds can be more easily kept free from weeds.

The seed should be planted in shallow drills, 4 to 6 inches apart, and covered with no more than one-quarter of an inch of earth. Forty to fifty seeds per linear foot of drill should be used; the entire surface of the bed should then be packed firmly with a board or light roller.

One pound contains about 65,000 seeds; these will plant at least 1,500 linear feet of seed drills, and, if seed beds 4 by 12 feet in size are used, will occupy about 1,000 square feet of nursery space, including paths.

The planted seed should germinate within from three to five weeks, and during the first year should reach a height of $1\frac{1}{2}$ to $2\frac{1}{2}$ inches. The young trees require partial shade during the first summer, after which they can endure the full sunlight.

PLANTING.

When 2 years old, seedlings may be transferred to the permanent site. It is better, however, to transplant them at this age into nursery rows, and place them in the plantation when 3 years old. Although this will increase the cost of the plant material, it will often pay, since transplanted stock is more hardy and vigorous.

In planting, the seedlings should be spaced from 4 to 6 feet apart each way. The poorer the situation the greater the number of trees required to maintain forest conditions and the closer must be the planting. The form of the desired crop must also be considered.

In pure stands Norway spruce develops to excellent advantage, and is satisfactory for commercial planting on a large scale. It cleans its bole well in such stands, preserves the soil fertility, and makes a perfect forest floor. In many instances, however, it may well be mixed with other species. The best associates are white and red pine, European larch, and chestnut.

CULTIVATION AND CARE.

The trees require no cultivation after planting. Their great tolerance enables them to survive the shade of brush and weeds and eventually to overtop them.

The greatest enemy of the spruce is fire, which should be carefully excluded from plantations.

Spruce stands should never be severely thinned, as the shallow root system renders the trees liable to be thrown by the wind. This damage is especially great in exposed situations. In case such destructive agencies as insects or fungi appear, specimens, accompanied by an account of the character of the injury, should be sent to the Department of Agriculture for identification and recommendations for their control.

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United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET NO. 13.

WHITE ELM (*Ulmus americana*).

FORM AND SIZE.

The white elm is a forest tree which frequently attains a height of from 100 to 120 feet and a diameter of from 6 to 8 feet. Its average size is somewhat smaller, although it is among the largest of our hard-wood trees.

When grown in the open the trunk almost invariably divides a short distance above the base, forming a wide-spreading, graceful crown. Forest-grown trees exhibit a wide divergence in form. The trunk is often clear of branches for over two-thirds of its length, straight and gradually tapering, surmounted by a compact crown. At the base the larger trees are often buttressed. The slender, interlaced twigs and the rough, flaky bark, divided into narrow ridges, are typical of the tree in all situations.

RANGE.

The natural distribution of the white elm is extensive. It ranges from Newfoundland to South Dakota and south through western Nebraska to Texas. The tree does not grow in pure stands, but occurs sparingly in mixture with the oaks, ashes, sycamores, yellow poplars, and other hardwoods.

The planting range of white elm is fully as wide as its natural distribution. It may be planted throughout the East and is especially well suited for prairie and plains plantations.

HABITS AND GROWTH.

White elm reaches its best development on deep, fertile, alluvial soil, moderately well drained. The species, however, readily adapts itself to soils less favorable or even to those decidedly poor. It is a hardy tree and will endure great extremes of temperature and moisture.

The elm is somewhat intolerant of shade. Its root system is deep, with an extensive lateral development. It is a fairly rapid-growing tree and often reaches great age. On poor situations both the rapidity of growth and the length of life are reduced.

Although seldom injured by wind, snow, or fungi, the white elm is subject to damage by insects. Borers often injure or kill the tree, but by far the greatest damage is done by the elm leaf-beetle and other defoliating insects. Because of them the planting of the elm as a park tree has been discontinued in many parts of the country. It is possible, however, to control the defoliators by early and thorough spraying with an efficient insecticide.¹

ECONOMIC USES.

The wood of white elm is strong, tough, fibrous, and difficult to split, but is not durable. It is in growing demand as a slack-cooperage material, and its use in this industry has resulted in a rapid increase in the stumpage value. The timber is also used for flooring, wheel stock, and shipbuilding, and in the manufacture of agricultural implements.

The hardness of the species and its indifference to soil conditions make it a very suitable tree for protective planting. For ornamental planting the suitability of the white elm is everywhere recognized. It is probably the most desirable of our hardwoods for such use.

METHODS OF PROPAGATION.

The white elm is a prolific seeder, bearing an abundant crop almost every year. Natural reproduction is usually by seed. European experience has shown that this species sprouts well, but in this country it is not advisable to depend on sprout growth, except from young trees and for the production of small-sized material. The seed ripen in May and should be collected and planted as soon as possible after ripening, since they retain their vitality but a short time. It is due to this fact that purchased seeds are often worthless. In all cases home-collected seeds are more satisfactory. The seeds may be gathered by sweeping them up from the ground or by shaking them from the trees into a canvas spread out below.

Plantations should be established with nursery-grown seedlings. The soil of the nursery should be rich, mellow, moist, and fairly well drained. If it is thoroughly worked, no seed beds are required. The seed should be planted in the spring, 60 to 80 seeds per linear foot, in rows 12 to 18 inches apart, and covered with not more than one-eighth of an inch of fine earth. The surface of the rows should be "firmed" with a light roller or a board and mulched until the seedlings appear.

There are 93,000 white-elm seeds in a pound, sufficient to plant nearly 1,200 linear feet of seed rows and to produce 20,000 to 30,000 seedlings. With rows 18 inches apart, 1,200 linear feet of drills would require 1,800 square feet for nursery rows. It is not necessary to shade

¹ For further notes on these insects see Farmers' Bulletin No. 99. Suggestions for the control of borers, scales, and other enemies of white elm will be furnished, on request, by the Bureau of Entomology of the Department of Agriculture.

the young plants, although at times partial protection from constant sunshine will be beneficial.

Further information concerning nursery practice is contained in Bulletin No. 29 of the Forest Service, which may be obtained upon request.

PLANTING.

When one year old the seedlings will be 5 to 10 inches high and should be transplanted to the permanent site. The use of older and larger seedlings is sometimes desirable, but in most cases one-year-old plants are suitable for commercial planting. Where the seedling forms a long root this should be cut back to 6 inches and the top pruned correspondingly.

Spacing will vary with local conditions. In general, moderately close planting is necessary to maintain forest conditions during the early life of the stand and to properly shade the ground and protect the soil. A spacing of 6 feet each way usually will prove satisfactory. In later life all stands should be thinned to encourage the best development of the remaining trees.

The white elm thrives in pure stands, but will also grow well when planted with more tolerant species, such as maple, white and red oak, and the ashes. Other trees suitable for planting with elm are black walnut, black cherry, tuliptree, and basswood.

For prairie planting it is essential that the soil receive thorough preparation. Where there is a heavy sod it should be turned under two or three years before the trees are planted and, if possible, a crop of cereals raised on the ground.

In the East no preparation further than preparing holes in which to plant seedlings is necessary.

CULTIVATION AND CARE.

Cultivation after planting is required only in the case of prairie plantations. In such situations the stand will be much benefited by the better moisture conditions and the suppression of weed growth resulting from cultivation. Eventually the young trees will shade the ground and establish forest conditions.

The young trees should not be planted where there is danger of them being overtopped and suppressed by brush growth and weeds. Plantations should be protected from fire and closely watched to detect the presence of injurious insects.

United States Department of Agriculture

FOREST SERVICE.

FOREST PLANTING LEAFLET 14.

WHITE PINE (*Pinus strobus*).

FORM AND SIZE.

The white pine is the largest of all conifers indigenous to the eastern part of the United States. On proper soils it may reach the age of 250 years or more and attain a height of 150 to 175 feet and a diameter of 3 to 5 feet. The crowns of mature white pines in mixed forests conspicuously overtop the surrounding hardwoods. Mature, forest-grown trees are characterized by straight, columnar trunks, destitute of branches for a distance of 75 to 100 feet from the ground, and thin, irregular crowns. At the base of the trunks of old trees the bark is thick and deeply furrowed and of a dark brown color, but becomes thinner and grayish toward the upper part of the tree.

RANGE.

The northern boundary of the natural range of white pine is from Newfoundland west to eastern Manitoba. Through the lake region the range extends west to eastern Minnesota and south to northern Iowa, Indiana, Illinois, and Ohio. In the East it originally occurred throughout New England and the Middle States, and, on the higher elevations of the Appalachians, southward to Georgia and Alabama. It was found in greatest abundance and reached its best development in the St. Lawrence Valley and the lake region. It usually grows in association with hardwoods and other conifers and reaches its largest size in mixture with the former.

White pine may be planted in suitable situations throughout its natural range, but for economic purposes planting should be restricted to nonagricultural lands in New England, Pennsylvania, New York, the Lake States, and the higher slopes of the Appalachians, and should be resorted to only when conditions render natural replacement impracticable, since in many situations, if the land is protected from fire, white pine will extend itself rapidly by natural seeding. Much of the abandoned agricultural land in New England may be profitably planted with this tree, which can be recommended for reforesting burned and cut-over areas generally throughout its economic planting range.

HABITS AND GROWTH.

White pine grows naturally and best in a cool climate on a fresh, light, deep, and sandy soil, with a porous subsoil. It readily adapts itself to both dry and moist soils, for it is found on the poorest and dryest sand and on steep, rocky slopes, and also on moist clay flats and river bottoms, provided the latter are not continuously wet. It is capable of disputing possession with hardwoods, even on fresh, medium-heavy clay and loam soils. It will endure windy and cold exposures, but should not be planted near the seacoast, as it can not withstand strong sea breezes.

White pine can endure considerable shade for a number of years, but as it becomes older it requires more and more light for its development, and after it is 40 or 50 years old the crown demands full sunlight. On this account white pine is best grown in mixture with slower growing hardwoods or other conifers, which will not overtop or shade it from above.

In artificial plantations or on abandoned farms which have been reforested naturally, white pine usually grows much faster than in the forest, especially during the early years. Records of plantations in New England show that the average growth of the larger trees ranges from one-fourth to one-third of an inch in diameter annually. It is possible in the eastern portion of the United States to produce saw timber in from sixty to seventy years. Smaller trees suitable for box boards and match blocks can be produced in thirty or forty years.

Owing to the thinness of its bark, young white pine is very susceptible to injury by fire, which must be most carefully excluded from plantations; but between the fifth and twentieth years the greatest cause of injury to the white pine is a weevil which in the grub stage mines in the terminal shoot and causes a crooked stem. Repeated attacks make the tree unmerchantable.

ECONOMIC USES.

The wood of the white pine is soft, light, straight grained, and easily worked, and will not warp. It was formerly used to a great extent for general construction, but on account of its growing scarcity and high price it has been largely superseded for this purpose by other woods. The better grades of this lumber are still used in naval construction—for decking, interior finishing, and spars.

Second-growth white pine is used principally for low-grade lumber, match blocks, box boards, wooden ware, and straight-stave cooperage. Where a demand for this material exists, white pine on nonagricultural lands will prove of economic value. Throughout the manufacturing regions of New England, wherever there is a market for small material, white pine will prove the most profitable conifer that can be grown on poor soils.

Within its range of economic planting white pine forms a very satisfactory windbreak or shelterbelt.

METHODS OF PROPAGATION.

White pine reproduces only from seed. Plantations should be started from nursery-grown stock rather than from seed, which usually gives unsatisfactory results.

If only a few hundred plants are desired, it usually is cheaper and easier to buy them from a nurseryman than to raise them, but if several thousand plants are needed it will be cheaper to raise them from seed. Purchased stock should be secured in the early spring before planting time, and upon receipt should be unpacked immediately and the roots dipped into a bucket containing thin mud. The trees should then be heeled-in in a shady place to await planting time, care being taken that the foliage does not become covered.

If the trees are to be grown in a home nursery, the seed may be purchased, but a large saving may be made by collecting it in the neighborhood, if this can be done. Cones should be gathered during the latter part of August or in September, before they begin to open. They may be picked from standing trees, or from felled trees if lumbering operations are being conducted nearby. When gathered, the cones should be spread out on a sheet or floor, where they will be exposed to the sun yet protected from wind and rain. Within a week they will open and allow the seed to drop out. A thorough stirring will separate the seed, after which the cones may be raked away. One bushel of cones will yield from one-half pound to 1 pound of clean seed, which will average from 29,000 to 30,000 seeds per pound. Seeds may be stored over winter by placing in small sacks and hanging the sacks in a cold, dry place.

The most successful method of raising seedlings is by sowing the seed in nursery beds. Seed beds should be composed of fine, loose, fairly fertile soil, moderately moist but always well drained. The soil must not be too rich, otherwise the seedlings will suffer when transplanted to the less favorable conditions of the permanent site.

A convenient size for seed beds is 4 by 12 feet, with a path about 18 inches wide between the beds, so that the plants can be weeded and cared for with ease. The seed should be sown in drills, 4 to 6 inches apart, and lightly covered with fine earth. Sowing should not begin until the ground is warm enough to cause rapid germination. Seed may be safely sown at the time garden vegetables are planted. After a seed bed is sown the surface should be "firmed" with a board or light roller.

The plants will begin to appear in from three to five weeks. Like other conifers, they will require partial shade during the first season, but subsequently can endure full sunlight, especially in New England.

A shade frame of lath supported 18 inches above the bed will serve the purpose.

One pound of white-pine seed is sufficient to sow 500 linear feet of seed drill, or about 200 square feet of seed beds, with drills 6 inches apart. Even with proper care some seed may fail to germinate promptly, but about 10,000 plants may be expected for every pound of fertile seed sown. White-pine seed retains its vitality for several years, and, when kept in cold, dry storage, a fair percentage has been known to germinate after five years. Fresh seed, however, is always to be preferred.

Two years after sowing, the seedlings should be transplanted in the spring from the seed beds to nursery rows, in order to develop a good, fibrous root system. They may be set out 3 inches apart, in rows from 12 to 18 inches apart. The roots should be set slightly deeper than they were before. The best method of transplanting is to open a shallow trench of the proper depth with a spade and set the plants by hand, carefully covering the roots of each plant with fine soil and gently firming it. Transplants, if thoroughly cultivated and weeded, will be ready for final planting at the beginning of the fourth season. At this age they should be 6 to 9 inches in height and have a well-developed system of fibrous roots.

In the early years of the white pine a very injurious fungus must be guarded against. If the soil becomes soaked, or sufficient light and air are withheld, ideal conditions for the action of the fungus exist, and the usual result is the "damping off" of large numbers of the young trees. In shaded seed beds, when the quantity of rain is sufficient to endanger the young trees, the "damping off" may be checked by so raising one side of the shade frame that it acts as a partial roof. Dry sand sprinkled over the seed bed will usually tend to hold the fungus in check.

Birds and field mice are often very troublesome around coniferous seed beds. If danger from such sources is expected, the seed may be coated with red lead mixed with linseed oil before sowing. This is distasteful to most birds and rodents and is usually quite effective. Another method is to protect the beds by netting and similar devices until the seedlings are sufficiently developed to be free from danger.

PLANTING.

White-pine seedlings should be planted on the permanent site in the early spring, when the ground is dry enough to work. In most cases the site will not need preparation previous to planting.

The roots must not be allowed to become dry during the planting. Even brief exposure of the roots to the sun and air will cause the plants to die.

The distance apart at which the trees should be planted depends upon the character of the site and whether the pines are to be planted in

mixture with other trees or in a pure stand. The usual distance is 6 by 6 feet apart.

In pure plantations white pine produces excellent forest conditions, but it is also adapted to growth with a number of other species, of which chestnut, European larch, Norway spruce, red oak, and hard maple are the more important. Chestnut is a very desirable tree for mixture with white pine on well-drained soils which are not calcareous, but as the planting range of chestnut does not, except in Vermont and New Hampshire, extend above the forty-second degree of latitude, it can not be used in mixture except within a limited area. In Pennsylvania, Michigan, Wisconsin, Minnesota, and northern New York white pine may be mixed with European larch, Norway spruce, or hard maple, and on soils adapted to red oak the latter may be used to advantage. In mixture with chestnut or European larch, white pine should constitute at least two-thirds of the stand, spaced according to the following diagram:

[6 feet by 6 feet.]

P	P	S	P	P
P	S	P	P	S
S	P	P	S	P
P	P	S	P	P

P=white pine. S=chestnut or European larch.

Mixed with other species, the stand should be composed of an equal number of white pine and the associated species planted alternately.

CULTIVATION AND CARE.

The cultivation of white pine in plantations throughout the eastern part of the United States is unnecessary. Persistent dead branches should be removed when possible, but it is not advisable to prune live ones. Where there is a demand for small material the stand may be profitably thinned at the age of 20 to 30 years, removing at this time all suppressed or intermediate trees which are not needed in the stand to shade the ground or to assist in naturally developing the large trees.

Since the bark of young trees is thin and easily damaged, fire must be kept out of stands, as injuries from this source cause rapid decay.

Information regarding general nursery practice and planting may be obtained from the publications of the Forest Service, which will be forwarded upon request. Insect damage should be reported promptly and specimens mailed to the Bureau of Entomology of the United States Department of Agriculture, where they will be identified and measures suggested for their control.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 15.

SCOTCH PINE (*Pinus sylvestris*).

FORM AND SIZE.

The Scotch pine closely resembles the red pine of North America. In Europe, in the region of its best development, it commonly attains a height of 120 feet and a diameter of from 3 to 5 feet. For a considerable distance above ground the stem is comparatively smooth and free from branches. In the forest the crown is short and compact, extending not more than one-third the length of the bole. The bark is usually deeply furrowed and, on the upper portion of the trunk, is distinctly reddish in color.

In portions of the Middle West planted trees of this species are often entirely different in appearance from the usual form, being scrubby and distorted. This poor development is probably due not to unfavorable soil or climatic conditions, but to the use of some inferior variety or of seed from regions not well adapted to the growth of the tree.

RANGE.

In this country Scotch pine does not occur naturally. Abroad it is widely distributed, ranging throughout the greater part of Europe and through northern Asia southward to Asia Minor and Persia. In the region of its natural distribution extensive planting has greatly increased its occurrence, until at present it is probably the most important forest tree in Europe.

In the United States the Scotch pine can be planted over a wide area, including New England, the Middle and Lake States, the Dakotas, and especially the prairie States, such as Nebraska, Iowa, and Kansas. The ability of this tree to thrive in situations where the atmosphere is exceedingly dry admirably adapts it to the prairie States. Little commercial planting has been done in this country, although many small groves and isolated trees indicate its fitness to the regions named.

HABITS AND GROWTH.

The Scotch pine is quite indifferent to soil requirements. In Europe it grows on heavy, peaty soils, and from that extreme on all classes of soils to dry, sterile sand. Good growth depends upon the physical

structure rather than upon the chemical composition of the soil. The best development is found on a deep, sandy loam containing considerable lime and underlaid by a fresh, well-drained subsoil.

In common with the moderate demands of the Scotch pine for mineral food is its extreme hardiness not only in dry, porous soils, but also in a dry climate.

The species is very intolerant of shade, in this respect exceeding all of our common trees, with the exception of the larches, aspen, and birch. It demands much more light than does the white pine. Notwithstanding this characteristic, moderately close planting is required to secure clear timber, for although the lateral branches are easily killed by shade they persist for a long time unless suppressed while young.

The rate of growth of this species in the United States is not well known. It is safe to say, however, that its growth is fairly rapid, planted groves in this country seeming to support the assertion that this growth equals that of our red pine.

In Europe the tree is subject to damage from a number of insects, but in America it appears free from injury. At present the general excellence of the tree will fully justify its wide use.

ECONOMIC USES.

In this country, except for fuel, no practical use has ever been made of the Scotch pine. Abroad it is the most important wood of commerce, furnishing the famous "red" and "yellow deals" of the British lumber trade. The wood is strong, close grained, highly resinous, and elastic, but not durable in contact with the soil. Despite this drawback, large quantities are used as cross-ties and pit props, its value for such uses often being increased by impregnation to resist decay.

Small-sized material is widely used for staves, heading, box boards, etc., but the great use of the timber is for general construction purposes. Its strength and elasticity, together with the ease with which it is worked, adapt it admirably for carpentry of all sorts.

Although inferior in many respects to our white pine, the Scotch pine will form an excellent substitute, and its great hardiness commends it for wide planting in the United States. It is well suited for windbreaks and shelterbelts and has already been so used in the Middle West.

METHODS OF PROPAGATION.

The Scotch pine grows from seed, which it produces abundantly every two or three years; hence plantations must come from seedlings or from seed sown on the permanent site. Seed should be purchased abroad, preferably from Russia or Scandinavia, since experience has taught that trees grown from such seeds are, as a rule, hardier and produce timber of better quality than trees grown from seed collected in Germany.

Direct seeding is not usually successful; hence, in establishing the plantation, the use of nursery-grown seedlings is recommended. The nursery should be located on high, well-drained ground of moderate fertility. When thoroughly prepared, the ground should be laid out in seed beds 4 by 12 feet in size, separated by paths 18 inches wide.

Seed should be sown in drills 4 inches apart running across the bed. They should be sown thickly—25 to 30 per linear foot—and covered with no more than one-fourth of an inch of fine earth. In a pound there are nearly 75,000 seeds, or enough to plant 2,500 linear feet of seed rows, covering about 1,260 square feet of nursery space. At least 37,000 seedlings can be grown from 1 pound of seed. After planting, the entire surface of the bed should be “firmed.” During the first season the young trees demand partial shade, such as is furnished by the common lath nursery screen. After this they require no protection from the full sunshine.

Seedlings may be left in the nursery from one to three years. If two or three year old stock is desired, the plants, to secure proper root development, should, when one year old, be transplanted into nursery rows. The transplanted trees should stand at intervals of 4 inches in rows 6 inches apart.

PLANTING.

Although for favorable situations younger plant material may be suitable, the use of three-year-old transplants is advised. At this age the young trees will have reached a height of from 9 to 12 inches and formed a vigorous root system capable of immediately establishing the tree.

In the plantation the trees may be spaced from 4 to 6 feet apart each way, depending upon the quality of the locality. On somewhat unfavorable situations the closer planting is advisable, but usually planting 5 by 5 feet apart is best. To secure proper form development the trees require considerable crowding while young, hence wide planting should never be practiced.

Scotch pine may be grown pure or mixed. It should never be associated with heavy-foliaged trees of equal or more rapid growth. Suitable associates are European larch, Norway spruce, white pine, and red pine.

CULTIVATION AND CARE.

Except where there is a heavy sod growth, the Scotch pine requires no cultivation after planting. In the prairie country the younger trees should be cultivated until able to compete successfully against encroaching grasses. Stands should be fully protected against fire and trespass. Any insect damage should be reported and specimens sent to the Bureau of Entomology, Department of Agriculture, for information as to the nature of the pest and methods of control.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 16.

FENCE-POST TREES.

REQUIREMENTS.

In planting trees for fence-post production the first and most important requirement is the selection of suitable species. A fence post should be made from wood of moderate strength, able to hold staples well, and durable in contact with the ground. Numerous trees have these characteristics, but to make a successful plantation and to secure early returns the species chosen should, in addition, be of rapid growth and well adapted to the locality. Nearly all the older forest plantations in the prairie States were made for protective purposes. Rapid-growing species, such as cottonwood and silver maple, were chosen. In many cases they were not adapted to the locality, and failed. Those plantations which succeeded are now furnishing fuel and some lumber, but not the fence posts the market demands. In more recent years the importance of growing more durable timber has been recognized. A forest plantation may often serve both as a woodlot and as a shelter-belt for crops, stock, and farm buildings. If trees suitable for fence posts are grown, they will furnish the desired protection and also yield a salable product.

SPECIES.

The best species for post production are chestnut, European larch, catalpa, black locust, Osage orange, and Russian mulberry. None of these trees should be used except within their economic planting range and on soils adapted to their growth. In States where several of these trees can safely be planted, the choice will naturally fall on the best grower or the one that will meet the special need of the owner. Elsewhere other less valuable species may be preferable because of their hardiness. Thus, in the semiarid region where other species would not thrive, green ash and honey locust have been grown with good results. These woods are fairly durable if well seasoned. White willow also has been extensively grown for fence posts over a broad region in the Middle West. It has the advantage of unusually rapid growth, and the seasoned wood lasts several years. But the use of any of these species is

unwise where more durable trees can be grown. The advisable planting range of the species recommended above is as follows:

Chestnut.—Light, porous soils in southern New England, New York, Pennsylvania, Ohio, and other States within its natural range of distribution. It is not adapted to the soil of the prairie States or to limestone formations.

European larch.—Well-drained sites in New England, New York, Pennsylvania, Ohio, Indiana, Illinois, Iowa, Michigan, Wisconsin, Minnesota, and the eastern parts of the Dakotas and Nebraska.

Hardy catalpa.—Deep, fertile soils with sufficient moisture and good drainage in Ohio, Indiana, Illinois, Iowa, Missouri, eastern Nebraska, eastern Kansas, and eastern Oklahoma.

Osage orange.—A variety of soils in the central and southern portions of Ohio, Indiana, Illinois, Iowa, and eastern Nebraska; favorable situations in western Nebraska, Kansas, and Oklahoma, eastern Colorado, and New Mexico.

Black locust.—Well-drained soils from the Rocky Mountains to the Atlantic coast; but in the Dakotas, Kansas, Nebraska, Iowa, Illinois, Indiana, Ohio, and Pennsylvania planting is wholly or partially prevented by injuries caused by the locust borer. West of the Rockies the black locust has been planted to a limited extent with marked success and with entire immunity from the attacks of insect pests.

Russian mulberry.—Kansas, Oklahoma, and the Indian Territory. Useful in those localities where better species can not be grown.

PLANTING.

In propagating forest trees for post production the first essential step is a proper selection of species; the second is the careful performance of every detail of the planting operations. In the prairie States it is usually necessary to prepare the site as for a field crop. Hardy catalpa needs thorough soil preparation, regardless of the region.

Care and promptness must be exercised in setting the trees. The stock should be planted as soon as possible after it is on the ground. The roots of all the young trees must be kept moist and the planting done carefully and thoroughly, with special attention to packing the dirt firmly around the roots. Even after a wise choice of trees, failures frequently result from improper handling and careless planting.

If post production is the primary object, any of the species mentioned may be planted pure; if it is secondary, mixtures, such as chestnut with oaks, or larch with pines, oak, or chestnut, may be used.

The best spacing distance depends largely upon the species and upon the local conditions of soil, topography, and annual rainfall. Generally speaking, the trees should be spaced from 4 to 6 feet apart each way, but in the prairie States of the Middle West, where cultivation is necessary, a spacing of 3 or 4 feet in rows 6 or 8 feet apart is often wise.

CULTIVATION AND CARE.

After the planting has been done, plantations in the prairie States should receive careful cultivation several times each season for two or three years. Loosening the ground and forming a dust mulch retards evaporation and protects the trees from encroaching grass. Unless the soil is carefully cultivated, forest plantations in many situations will almost immediately fail. Hardy catalpa plantations should always be cultivated.

To secure a straight, clean sprout for the main stem, such trees as hardy catalpa, Osage orange, Russian mulberry, and locust may be cut back to the ground during the winter of the second year after planting. During the first season of sprout growth one good, tall sprout should be chosen and the rest cut off. In this way the tendency to irregular and crooked growth may be avoided.

To force them into good proportions for fence posts, trees like Osage orange and Russian mulberry should, except when in shelterbelts, be kept well pruned of low side branches. The hardy catalpa sheds its dead branches very slowly, often letting in decay. It is therefore advisable, if the best results are desired, to keep the dead limbs trimmed off.

COST AND RETURNS.

The original cost of establishing a plantation ranges, according to local conditions, from \$8 to \$15 per acre. This does not include the expense of any subsequent treatment, such as cultivation or pruning.

The conditions of the site, the method of planting, and the care which has been given the plantation all materially affect the yield. Larch, hardy catalpa, and Osage orange should in fifteen years yield from 500 to 1,500 posts per acre. Plantations growing under excellent conditions have at this age yielded as high as 2,000 posts per acre.

If the site and species have been wisely selected and proper care has been exercised in planting and culture, profitable returns may be expected from forest plantations for post production. In addition, the convenience of a home supply of posts and stakes, and the protection afforded by the trees, enhance the value of the plantation. The exact amount of profit must depend, however, on the yield of posts per acre and the prices obtainable, which vary greatly in different localities. Examinations of larch plantations in Illinois, Iowa, and eastern Dakota showed that the annual financial returns per acre were approximately as great as from field crops properly managed, and the plantations required less care. In Illinois, also, hardy catalpa plantations on suitable soils gave returns equal to or somewhat greater than the usual farm crops.

Two hardy catalpa plantations were established in Pawnee County, Nebr., in 1890 and 1889, respectively. By contrast, they show well the possibilities and limitations of the species. No. 1 was planted on well-

prepared virgin prairie soil; No. 2 on adjacent worn-out farm land. The soil was a deep, sandy loam underlaid with clay. The plantations received cultivation and pruning at the proper time.

PLANTATION No. 1.

<i>Cost per acre.</i>		<i>Returns per acre.</i>	
Plants, 2,722 at \$1.15 per thousand -----	\$3.13	First-class posts, 647 at 14 cents	\$90.58
Preparation of the ground, cultivation, and pruning -----	18.46	Second-class posts, 1,363 at 9 cents -----	122.67
	<hr/> 21.59		
Interest on \$21.59 for 14 years at 5 per cent interest compounded -----	21.16		
	<hr/>		
Total cost at end of 14 years -----	42.75	Total returns at end of 14 years -----	213.25
Net profit per acre, \$170.50.			

This profit represents an annual net return, with 5 per cent compound interest, of \$8.69 per year.

PLANTATION No. 2.

<i>Cost per acre.</i>		<i>Returns per acre.</i>	
Plants, 2,722 at \$1.15 per thousand -----	\$3.13	First-class posts, 18 at 14 cents	\$2.52
Preparation of the ground, cultivation, and pruning -----	18.46	Second-class posts, 510 at 9 cents -----	45.90
	<hr/> 21.59		
Interest on \$21.59 for 15 years at 5 per cent interest compounded -----	23.29		
	<hr/>		
Total cost at end of 15 years -----	44.88	Total returns at end of 15 years -----	48.42
Net profit per acre, \$3.54.			

This profit represents an annual net return, with 5 per cent compound interest, of \$0.16 per year. Five years' additional growth would show a much greater return proportionately.

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FOREST PLANTING LEAFLET 17.

EUROPEAN LARCH (*Larix europæa*).

FORM AND SIZE.

The European larch is a deciduous conifer, similar in form and size to our native tamarack. The long, thin-foliaged, spire-like crown is very characteristic. When grown in the forest the bole is very straight and clean and the crown greatly reduced in size. The tree is of medium proportions, but occasionally reaches a height of 80 to 100 feet and a diameter of 2 to 3 feet.

RANGE.

The European larch is not indigenous to the United States. Its natural range is confined to a somewhat limited region in Central Europe, where it grows best on the fresh soils of the lower mountain slopes. It has been widely planted abroad, and was introduced into England as early as 1629.

In the United States small plantations have been made from New England to South Dakota. The exact limits of the region in which planting is advisable can not be given, but it is evident that commercial plantations may be established throughout the Northeastern States and westward through the Central and Lake States to South Dakota and the prairie region. In Iowa, eastern Kansas, and Nebraska European larch is, when planted in suitable situations, among the most promising of our conifers.

HABITS AND GROWTH.

The larch requires favorable soil conditions. The soil should be deep, light, moderately fertile, and fresh, but well drained both in the upper layer and in the subsoil. This tree possesses a deep root system like that of Scotch pine and oak. When the land is wet the tree may start vigorously, but it will soon become spongy at the base and rot. It will grow on comparatively poor but not on sterile soil.

The species is distinctly intolerant, demanding more light than any other of our conifers and equaling in this respect our most intolerant hardwoods, such as aspen and locust. In its natural state it is never found in pure stands, occurring only in small groups or as isolated individuals among more shade-enduring species.

The larch grows faster than most species. It is one of the most desir-

able trees for planting in the eastern and central parts of the United States.

Several years ago the larvæ of a sawfly almost entirely killed the native tamarack of the Northeast, and young trees are still seriously injured by insects. As yet no serious damage by this insect has been reported from plantations of the European species in the West, but the small plats which exist in New England have been badly injured and in some cases nearly destroyed by insect pests. On low ground a fungus known as *Trametes pini* often attacks the larch and so destroys the substance of the wood that the tree breaks down in even a slight wind. In Europe pure plantations often become the prey of the fungus.

ECONOMIC USES.

The wood of the larch is heavy, hard, strong, flexible, and very durable in contact with the ground. When grown on good soil it is yellowish-white, but in cold, elevated situations it is reddish-brown and much harder. Because of its strength and durability, it is very valuable for poles, posts, cross-ties, etc., and is largely used in shipbuilding.

METHODS OF PROPAGATION.

The larch reproduces entirely by seed. It is best propagated by transplanting 2-year-old nursery-grown seedlings or transplants to the plantation. The seeds are borne abundantly in small, upright cones, and are easily collected. Care, however, should be taken in collecting them, for the old, seedless cones, which remain for three or four years, are easily mistaken for new ones. The number of trees in this country that have reached fruiting age is limited, and it is often necessary to use imported seeds, which may be obtained direct from foreign dealers or through the larger home seedsmen.

Although a deciduous tree, the larch is a conifer and should be treated as such in all nursery and planting operations. Nursery culture is simple and should be conducted according to the general rules given in Bulletin 29 of the Division of Forestry. Nursery seed beds should be prepared in moist loam and the seeds sown in shallow drills 6 inches apart and lightly covered with fine dirt. Partial protection from the sun and beating rain should be given the young seedlings for the first two years. For this purpose the common lath screen described in the bulletin mentioned is simplest. One pound of seed, containing 72,000 seeds, is sufficient to plant 400 feet of seed drills, and will produce about 25,000 plants. These will occupy about 250 square feet of nursery space.

PLANTING.

Seedlings may be planted when 2 years old. The planting should be done very early in the spring, as the buds start early. The trees should be placed from 4 to 6 feet apart each way, according to local conditions.

In the Middle West the narrower spacing is preferable. In prairie planting the soil should be thoroughly prepared, but in the East such preparation is not necessary.

Mixed plantations are most desirable, since European experience shows that pure plantations of larch do not thrive for any length of time. The larch may be planted to advantage with the following species: Chestnut, white and green ash, white and slippery elm, Scotch pine, red pine, white pine, Norway spruce, and red cedar. Often three or four of these species may be advantageously combined, as the European larch, white elm, white ash, red cedar, or white pine. In such mixtures, however, considerable care and skill are required in the thinnings, and simpler combinations are usually preferable. Chestnut and larch, and red or white pine and larch, make admirable mixtures for planting on a large scale. In such mixtures the larch should be in the proportion of one to three or more.

Because of the imperious demand of the larch for light, pure stands are decidedly unsafe; the tops demand considerable growing space, and the weaker trees die out to such an extent as to expose the soil and impair forest conditions. Furthermore, pure forests are much more liable to serious insect damages.

CULTIVATION AND CARE.

In the prairie region forest plantations of European larch should be thoroughly cultivated until the trees are able to compete successfully with encroaching grasses. In the East cultivation after planting is not required.

Plantations should receive full protection against fire and stock. Any serious damage from insects or fungi should be reported and specimens sent to the Department of Agriculture for suggestion as to methods of control.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 18.

CHESTNUT (*Castanea dentata*).

SIZE AND FORM.

The chestnut is among the largest of our hardwood trees, and in the region of its best development has been known to reach a height of 120 feet and a diameter of 13 feet. Throughout the greatest part of its range, however, it is much smaller, with an average height of 80 to 100 feet and a diameter of from 2 to 4 feet. When grown in the forest it forms a tall, clean, fairly cylindrical trunk; in the open it assumes a form like a fruit tree, with a short, thick trunk and broad, spreading crown. The bark is thick and deeply ridged, and the root system is extensive, in both lateral and vertical development.

RANGE.

The chestnut is distributed throughout the eastern part of the United States at elevations varying from sea level in Massachusetts to 5,000 feet in North Carolina. It ranges from southern Maine southward through New England, but in this region is most abundant in the lower valleys of the Merrimac and Connecticut rivers. Except near the sea, it is common in Rhode Island and Connecticut and as far south as Delaware. It is found also in the Province of Ontario and in the Eastern States, especially in New Jersey, Pennsylvania, and parts of Maryland. Farther south it is found along the Appalachians to Alabama, growing well in all soils above 2,000 feet in elevation, but less abundantly below. In the Middle West it is confined to Michigan, Indiana, and Illinois.

Large areas throughout the East, particularly in New England, New York, Pennsylvania, and Maryland, are well adapted to chestnut. Outside of its natural range, however, the success of this species is doubtful. Chestnut can be grown fairly well throughout Missouri and southeastern Iowa, in the eastern counties of Nebraska and Kansas, and in the southern half of Minnesota, but nowhere on prairie soil is it long-lived or of first-rate growth. In Colorado it grows well under irrigation, and would probably succeed in other parts of the West if well watered. If it is planted too far north the shoots fail to become woody before they are nipped by the early frosts. The tree will endure the heat and cold of its natural home, and will remain thrifty in sunny, dry situations, but is very susceptible to injury from hot winds.

HABITS AND GROWTH.

Chestnut will thrive on a variety of soils, from almost pure sand to coarse gravels and shales. On limestone soils, however, it nowhere makes good growth. In general it prefers the dry, well-drained, rocky land of the glacial drift to the richer, more compact alluvial soil of the lowlands. Chestnut does not need a rich soil so much as one whose physical structure insures good drainage. Light is essential to the tree, since it is somewhat intolerant of shade.

Few of our valuable hardwoods are more rapid in growth than chestnut. Seedlings usually attain a height of from 10 to 15 inches at the end of the first season. From then until the thirtieth year the annual height growth will average from 15 to 20 inches. Coppice sprouts make even more rapid growth during the same period, but in later life their growth falls off rapidly.

Ordinarily the chestnut, as a forest tree, is little troubled by insects or fungi. Several forms of borers work in the wood and under the bark, and their ravages are sometimes extensive. The nuts are attacked by the larvæ of two or more species of weevil, but to the timber grower this is not serious. Trunks of the young trees in warm situations are sometimes affected by a body blight, or "sun scald." The bark cracks and loosens on the south and west sides of the tree, and the affected portion finally dies. The extent of injury from this source is, however, not great. During the past ten or fifteen years a new disease of unknown cause has been doing considerable damage.

ECONOMIC USES.

Chestnut timber is in great demand. The wood is light, moderately strong, coarse-grained, and elastic. It works easily and is very durable in contact with the soil. In seasoning, the wood often checks and warps, but damage from this source is not serious. It is used in cabinet work and cooperage, and for fence posts, telegraph and telephone poles, ties, and mine timbers. The presence of tannin in the wood increases the demand for small-sized and inferior material, and large quantities are used in the manufacture of tanning extracts.

Except in portions of the Southern Appalachians, very little of the original chestnut remains, but the coppice reproduction is so rapid that a considerable supply of small-sized timber is still available. The excellent qualities of the wood insure a permanent demand and good price.

METHODS OF PROPAGATION.

Chestnut plantations may be established by direct seeding or by the use of nursery-grown seedlings. Seed may be purchased, or collected from trees in the vicinity. To prevent drying out and consequent loss

of germinating power, collected seeds should be kept stratified in moist sand until the following spring.

Home-grown seedlings are usually superior to those purchased from commercial dealers, and are much cheaper. The nursery should be located on fresh, well-drained, fertile soil, under conditions such as are usually present in an old garden spot. Thorough cultivation of the soil is required, but the preparation of seed beds is unnecessary.

Seed should be planted, 10 to 12 per linear foot, in nursery rows 18 inches apart. Care should be taken not to cover the seed more than 1 inch deep.

A bushel contains 6,500 to 8,000 nuts, sufficient to plant 650 linear feet of nursery rows and to produce at least 4,000 plants. These rows will cover an area of 975 square feet. While in the nursery, seedlings require careful cultivation and should be kept entirely free from weeds.

PLANTING.

When planting on permanent sites the trees should be set 5 or 6 feet apart each way, the width depending upon the quality of the site and the possible market for the product of thinnings. In good situations the wider spacing is advised.

If the trees are to be grown directly from seed without transplanting, seed spots should be prepared, spaced as above. Two or three seeds should be planted in each and covered about 1 inch deep with fine earth. Only one tree should be allowed to remain in each hill. This method is recommended by many, and where there is no danger of squirrels it will prove satisfactory and less expensive than the use of seedlings. In general, however, the seedling plantation will be safer and will give better results.

The system of management best suited to the chestnut is the pure coppice, with a rotation of from twenty-five to thirty-five years. Coppice makes more rapid growth than seedling forest, and produces timber in many respects superior. The species also grows well in mixtures, particularly with the white and red pines and the European larch, and also with the oaks, ashes, and maples.

CULTIVATION AND CARE.

On the prairies, plantations should be cultivated until the young trees are well established, but in the East cultivation is unnecessary.

If insects appear in alarming numbers in the forest, specimens, together with an account of their habits, should be sent to the Bureau of Entomology of the Department of Agriculture for identification and suggestions as to their destruction or control.

The greatest enemy of the chestnut, as of other forest trees, is fire, from which it should at all times be fully protected.

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 19.

WESTERN YELLOW PINE (*Pinus ponderosa*).

FORM AND SIZE.

The western yellow pine is one of the largest and most valuable of the pines. It ranges in size from a tree not more than 60 feet high in the arid portions of its range to one 200 feet in height and 6 feet in diameter on the western slopes of the Sierras. It has a straight and symmetrical stem and usually a long, spire-like crown, which, even in fairly dense stands, covers from one-half to one-third of the tree. The needles are from 6 to 10 inches long and usually grow in bundles of three.

RANGE.

The natural range of western yellow pine is throughout the United States west of the one hundredth meridian. It is most common in the Rocky Mountain and Pacific Coast ranges at medium altitudes.

The tree may be planted anywhere within its natural range and, in favorable situations, several degrees farther east. It is particularly well suited for planting in the sand-hill regions of western Nebraska and Kansas and on denuded watersheds in the Rocky Mountains and Pacific Coast regions below an elevation of 6,000 feet.

SILVICAL QUALITIES.

Western yellow pine is a very hardy tree and will endure great diversities of soil and climate. It is especially suitable for planting in dry regions where droughts are not too prolonged.

The conditions under which it usually grows prevent the tree from making a rapid growth. In the most favorable situations, however, its growth is fairly rapid.

Western yellow pine has suffered greatly from the attacks of bark beetles. The trees are usually attacked during August and September and die by the following spring. If a plantation is attacked by these insects, specimens, with description of the damage, should be sent to the Bureau of Entomology, Department of Agriculture.

Because of their long and heavy foliage, the young trees are sometimes borne down by deep snows.

ECONOMIC USES.

The wood, which is light, strong, dense, and moderately durable, is the most valuable one of the Rocky Mountains and the most extensively used. Because of its dense foliage and ability to grow in close stands, the tree forms an excellent watershed cover.

PROPAGATION.

Western yellow pine reproduces only from seed. Natural reproduction is abundant wherever there are old trees. The cones ripen in the fall of the second year, and the seeds can be kept over winter in any dry, cool place, and can be preserved several years with only a moderate loss of vitality.

Like most pines, the tree has a strong taproot, which in most situations penetrates to a considerable depth.

PLANTING.

In planting western yellow pine it is best to use trees from 2 to 3 years old which have been raised in nursery beds from seed planted in early spring. Because of the tendency to develop a long taproot it is necessary to transplant the seedlings in the spring when 1 year old to nursery rows, or to root prune them in the beds. This last plan is more economical and is advisable where a large number of seedlings are grown.

The young trees should be set out in their permanent places in April or early in May. They may be planted either in furrows or in holes made with a spade or mattock. As a rule the trees should be spaced from 5 to 6 feet apart each way. If success is to be attained, great care is necessary in protecting the roots from the air and in packing the soil down firmly around them.

It is usually best to plant western yellow pine in pure stands.

Additional details as to planting can be found in the planting leaflets, *How to Transplant Forest Trees*, and *How to Pack and Ship Young Trees*.

CULTIVATION AND CARE.

In many localities of the West where western yellow pine is planted, cultivation until the trees are thoroughly established will be very beneficial. Fire and stock should be kept out of the plantation, and it should be allowed to assume the character of a forest as soon as possible. Further information can be found in the planting leaflet on *How to Cultivate and Care for Forest Plantations on the Semiarid Plains*.

United States Department of Agriculture, FOREST SERVICE.

FOREST PLANTING LEAFLET 20.

RED CEDAR (*Juniperus virginiana*).

FORM AND SIZE.

The red cedar presents a wide contrast in form, varying in different parts of its range from the low, bushy type of the West to the conical and spire-shaped crowns of New England, Virginia, and Maryland. It grows to considerable size within the deep swamp lands of the eastern Gulf States, and attains its greatest dimensions on rich, alluvial bottomlands, where it occasionally has a height of 120 feet and a diameter of 3 feet, though its average size is much less. It is a long-lived tree, and often reaches an age of several hundred years.

RANGE.

Few American conifers are more widely distributed than red cedar. Its range extends from southern Nova Scotia and southern New Brunswick to Florida, and from North Dakota southward to the Colorado River Valley in Texas, though over much of this territory only scattered individuals or small groups occur. It reaches its best development south of the Ohio River, where dense stands formerly occurred in the foothills of the Cumberland Mountains, and in the valley of the Tennessee River in Tennessee and Alabama. Red cedar usually grows in mixture, but on the cedar barrens of middle Tennessee pure stands occur.

For economic planting the range is restricted to localities where protection is needed and where there is demand for fence posts. These include the Dakotas, Nebraska, Kansas, Oklahoma, Texas, eastern New Mexico, Colorado, and Wyoming. In addition, it is advisable and economical to plant red cedar in the regions of its best development wherever natural reproduction is not satisfactory.

HABITS AND GROWTH.

Few trees of the eastern part of the United States exhibit a greater indifference to soil and climate than the red cedar. It thrives in the valley of the St. Lawrence and in New England; on the hills and limestone flats of the Southern States; on exposed, semiarid situations in Kansas and Nebraska, and on the deep soil of the hummocks of the Gulf Coast, where the annual precipitation is 60 inches.

In general, it may be said that the best growth is attained in a rather light, loamy soil, containing lime, and that heavy clay and sand are not so favorable.

Full enjoyment of light is necessary for complete development, but good growth may continue for a few years under the shade of other trees.

On account of the great variety of conditions under which red cedar occurs, its rate of growth varies widely, but is usually rather slow.

Fires are highly injurious to red cedar, owing both to its thin bark and to its flat root system. They generally kill all the trees in pure stands. In mixed forests, where the soil is fresher and the fire less fierce, the trees rarely suffer immediate death, but the butts are charred and the decay characteristic of old cedars begins.

Attacks of various forms of fungi cause such injuries as "cedar apple," "witches' broom," and white and red rot. In the nurseries large numbers of good-sized trees are sometimes destroyed by a blight. A number of destructive boring insects feed on both the living and the dead trees, and the foliage is eaten by certain species of caterpillars.

ECONOMIC USES.

The wood is light and soft, with a fine, compact, even grain, susceptible of a high polish. Its great durability makes it valuable for posts and telegraph poles. In addition to the lead-pencil industry, which annually consumes a large amount of the best grade of material, various arts and industries make use of the wood. In naval construction it is employed for many purposes.

The value of red cedar for planting lies in its superior adaptability to unfavorable soil and climatic conditions. It stands pruning well and hence is largely planted for ornamental purposes, and occasionally for evergreen hedges, though it is not so well adapted for the latter purpose as *arborvitæ* and similar trees. On account of its ability to endure great climatic changes it is a valuable tree for windbreaks on the semi-arid plains. In Oklahoma, Texas, New Mexico, and in other regions where more rapid growing trees will not thrive, it can be profitably grown for fence posts.

Generally, faster-growing trees are to be preferred, since even on good soils red cedar timber of the best quality can not be produced in less than from seventy to one hundred and twenty years.

PROPAGATION.

Red cedar reproduces only by seed, which the pistillate trees bear in great abundance. Plantations should be started from nursery-grown trees and not from seed sown directly on the permanent site.

The seed germinates with difficulty, and seedlings, when a few weeks old, are subject to a fungus disease which occasionally causes heavy loss; hence the planter, unless he desires several thousand trees, should buy his stock rather than attempt to raise it himself.

Nursery-grown plants are generally rather expensive, but in many localities wild seedlings may be collected locally or purchased from dealers. These seedlings, if not large enough for planting, should be set out in the home nursery, there to remain for one or two years, when, having reached a height of from 10 to 12 inches, they will be of suitable size for permanent planting.

The seeds are inclosed in a globular, purplish-black berry, which is covered with a silvery bloom. These berries contain from 1 to 2 seeds each and mature in the fall of the first year, frequently remaining on the tree until late in the following spring. The berries should be collected late in the fall, or whenever they are thoroughly ripened. Once collected, the berries should be soaked for three or four weeks in cold water, until the pulp of the berry has rotted. The seed should then be separated from the pulp, mixed with sand, and kept moist until spring. Sowing may safely begin when garden vegetables are being planted.

Seed beds are best made in fine, loamy soil, moderately fresh, but always well drained. For convenient cultivation they should be about 4 by 12 feet in size, and separated by a path 2 feet wide. The seed should be sown in drills 6 inches apart, and lightly covered with fine earth. One pound of seed will sow about 640 linear feet of seed drills, or about 320 square feet of surface.

After the seed bed is completed the surface should be "firmed" with a board or light roller. Some of the seed may not germinate until the second season.

Like those of most conifers, the plants will require artificial shade during the first season; after this they can stand full sunlight. In the spring of the second season the seedlings should be transplanted into nursery rows 18 inches apart with 5 inches space between the plants. By the end of the second year the plants will be 7 or 8 inches high, and well rooted. At the opening of the third season, usually in March or April, it is best to transplant again in the nursery, with 8 or 9 inches spacing.

PLANTING.

The plants should be from 10 to 12 inches high when set out in the permanent site. If they have been purchased from a nurseryman they should be unpacked immediately upon arrival and their roots dipped in a "puddle" of earth and water. They should then be taken at once to a shady place and heeled-in. When planting begins, whether home-grown or purchased stock is used, the greatest care should be taken to keep the roots constantly moist. This can be done by keeping them wrapped in wet moss or by carrying them in a pail containing several inches of water. If the roots become thoroughly dry the plants will die.

For pure plantations on the dry upland soils of the West, spacing 4 by 4 feet is advised; on better and moister soils 4 by 6 feet or 4 by 8

feet. The planting must be done carefully and the earth packed firmly about the roots so as to give good contact and exclude the air.

The vicinity of orchards should be avoided, because the "cedar apple," a fungus very destructive to fruit trees, passes one of its stages on the branches of the red cedar. For windbreaks or shelterbelts on the high prairies in the Southwest a most desirable mixture is red cedar and Osage orange or honey locust. These should be planted 4 feet apart in alternate rows 6 feet apart. For fence posts the plantation should be made pure and the trees planted 4 feet apart in rows 6 feet apart.

CULTIVATION AND CARE.

Success with red cedar, especially in the simiarid region, will depend largely upon the character and extent of the cultivation. On such sites, for several years after setting, the plantation should be given frequent shallow cultivation. In river and creek valleys, where water is found near the surface, it is unnecessary to cultivate after the first two or three years.

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United States Department of Agriculture,

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FOREST PLANTING LEAFLET 21.

HONEY LOCUST (*Gleditsia triacanthos*).

FORM AND SIZE.

The honey locust in the forest usually attains a height of from 75 to 100 feet, and a diameter of from 2 to 3 feet, with a well proportioned trunk and crown. Under favorable conditions it occasionally reaches a much larger size. In the open it produces a short trunk and a broad, open crown. The trunk and branches are armed with rigid spines from 3 to 4 inches long, which frequently grow in large clusters. These spines are occasionally objectionable, but can be removed by pruning if desired. Many trees are partially or wholly free from spines, and this form is, naturally, most satisfactory for shade purposes.

RANGE.

The natural range of the honey locust is from western New York south to Georgia, and west through southern Ontario and Michigan to eastern South Dakota, and thence south to Texas. It is found most abundantly on the fertile, gravelly hills of central Kentucky, where it is the predominant tree. However, it reaches its best development in the river bottoms of southern Illinois and Indiana, where it is intimately associated with hickory, elm, ash, boxelder, Kentucky coffeetree, basswood, and black walnut. It also occurs in the prairie groves in Illinois, associated with oak, walnut, and other species. At the western limit of its range it grows in rich, moist soil along the streams.

This tree may be planted on good soils throughout its natural range, but for economic purposes planting should be restricted to Iowa, Nebraska, Missouri, Kansas, western Oklahoma, northwestern Texas, eastern Colorado, and Wyoming. The honey locust is one of the hardiest trees for upland planting in the semiarid regions of the Middle West. It demands a rather deep soil, and usually fails on shallow ground where cedar and pine can be planted successfully.

HABITS AND GROWTH.

The honey locust does best and reaches its greatest size on the deep, rich soils of river bottoms. On gravelly or heavy clay soil it does not

grow so well. Soil containing lime is especially favorable for it. The common soil of the plains and prairie regions is well suited to it and it thrives in western Kansas and Nebraska, where the rainfall is not more than half that of its native habitat.

It is very intolerant of shade, but has a tendency, when not crowded, to produce long branches near the ground, and hence it is an excellent tree to plant for hedges and windbreaks. In the Middle West the honey locust is equaled in drought-resisting power only by the Russian mulberry and Osage orange, and it endures severe winters to which these species would ordinarily succumb. The roots do not sprout unless they are injured in cultivation. It will stand cutting back when young, a quality which adds to its value as a hedge tree.

In favorable situations its annual height growth is from 1 to 2 feet, and its diameter increment from one-third to one-half of an inch. On the semiarid plains of western Kansas and Nebraska it will grow an inch in diameter in from three to four years.

Unlike the black locust the honey locust is not injured by the borer and leaf miner. Thus far it has proved uniformly healthy wherever planted. Rabbits sometimes gnaw the bark of the young trees during the winter, but the trees soon outgrow this danger.

ECONOMIC USE.

The wood of the honey locust is coarse-grained, heavy, hard, strong, and fairly durable in contact with the soil. It is used chiefly for fuel, fence posts, and poles. But it is as a living tree that the honey locust serves the most useful purpose, since within its range other species can be grown which are more valuable for their wood but less desirable for permanent trees. It is useful for hedges and shelterbelts, and for general planting to improve the conditions of a naturally treeless region. Honey locust makes an excellent street tree, and it is increasing in favor for that purpose, especially in western towns.

METHODS OF PROPAGATION.

The honey locust produces seed abundantly, and is easily propagated. The pods ripen in the fall. After they become dry and brittle the seed may be thrashed out without difficulty. Where possible, seed should be gathered from thrifty plantations in the neighborhood, since trees grown from such seed are likely to be better adapted to local conditions than those brought from a distance. The seeds may be sown in the fall soon after they have been collected, or stratified in moist sand over winter and sown in the spring. If sown at the latter time the seeds should be soaked in warm water until most of them swell. The swollen seeds should then be removed, and the remainder again treated with warm water. Seeds which have become very dry may require soaking for two or three days.

Immediately after the swollen seeds are removed from the water they should be planted in moist, rich soil, in rows from 12 to 18 inches apart. After they have been covered with from one-half to three-quarters of an inch of well-pulverized soil, the dirt should be firmed with a roller or board. The seed beds should be kept moderately moist until germination is complete.

Seedlings a foot or more in height can be grown in one season. This is a satisfactory size for general planting. If a large number of seedlings are required, the planter should grow them himself rather than purchase them from nurserymen, since home-grown trees can be produced cheaply and dug and planted when conditions are most favorable. If the season is unfavorable for transplanting, the seedlings may be left in the nursery rows another year.

PLANTING.

Planting should be done as soon as the growing season begins. One or 2 year old seedlings should be used. In general, the most satisfactory spacing is 4 feet by 6 feet, but in localities where rainfall is light and extensive cultivation is necessary, 4 feet by 8 feet is more advantageous, because it permits of easy cultivation. If the planter does not intend to give the trees much cultivation he should plant closely, distributing the trees evenly over the ground and setting them near enough together to shade out the weeds.

CULTIVATION AND CARE.

Through the early years of growth frequent shallow cultivation should be given, particularly on the semiarid plains and prairies, both to destroy the weeds and to conserve the moisture. The cultivation should be continued until the trees are sufficiently large to shade out the weeds and grass. Live stock and fire should be entirely excluded from the plantation.

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United States Department of Agriculture, FOREST SERVICE.

FOREST PLANTING LEAFLET 22.

HACKBERRY (*Celtis occidentalis*).

FORM AND SIZE.

Hackberry is not a commercially important tree, but throughout the Middle West it is widely planted for a shade tree, and it is suitable for mixture with other species in windbreaks. In form, hackberry is usually characterized by a single stem with warty bark and a broad, conical crown. In good situations the tree often attains a diameter of 2 feet and a height of 80 feet.

RANGE.

The natural range of the hackberry extends from Massachusetts to Oregon and from Canada to Mexico and Florida. It seldom forms pure forests, but grows in mixture with elm, walnut, bitternut hickory, pecan, ash, oak, and many other broadleaf trees. Although widely distributed, its natural range of economic importance is chiefly limited to the river bottoms and creek valleys of the Middle West. It may safely be recommended for planting on the plains and prairies, from Texas to Canada, but the low economic value of its wood, except for fuel, makes its use inadvisable where better timber trees can be grown. It is an excellent shade tree and rivals the white elm in many of our western cities.

HABITS AND GROWTH.

The hackberry will, of course, thrive better on a fertile soil than on a poor one, but its ability to grow on almost sterile soils is one of its best qualities. It is characteristic of the tree to live and bear seed in situations where almost any other tree would die. In the more humid regions it grows on dry and sometimes almost barren soil, while in the semiarid plains it thrives best along the watercourses. A limestone soil seems to be especially favorable.

Its great hardiness where there is a scarcity of moisture makes it one of the best trees for planting in the semiarid regions adjacent to the Rocky Mountains. It will not endure swampy soil.

It is tolerant of shade and consequently thrives in mixtures. In rich alluvial soil the annual diameter growth is sometimes one-third of an

inch, but usually it is much less. Hackberry is sometimes found in situations so unfavorable that fifteen years or more are required for an inch of diameter growth. Its period of most rapid growth is between the twentieth and fortieth years. It reaches an age of from one hundred and fifty to two hundred years.

The hackberry is generally a healthy tree, though often its leaves are covered with insect galls. In case harmful insects appear in threatening numbers, specimens accompanied by a full description of their depredations should be sent to the Department of Agriculture for identification and suggestions for their destruction or control.

ECONOMIC USE.

The wood of the hackberry is of medium weight, hardness, and strength, and is rather elastic. It makes excellent fuel, almost equaling hickory, and is used also in the manufacture of cheap furniture. The technical qualities of hackberry wood resemble those of elm and white ash, and it is occasionally used as a substitute for them. It is not durable in contact with the soil, and, like hickory, when used unpeeled above ground is likely to become worm-eaten. When peeled and properly seasoned, hackberry poles serve many useful purposes on the farm.

It is chiefly as a living tree in regions where trees of any kind are highly prized that the hackberry is of greatest economic value. In mixture it serves a good purpose by shading the ground and furnishing litter to enrich the soil.

METHODS OF PROPAGATION.

The hackberry is usually propagated from seeds. When a seedling has its top killed, it readily sprouts from the root, but large trees rarely sprout after cutting.

The hackberry bears seeds abundantly. The fruit is a bluish-brown drupe about the size of a pea. The thin, fleshy layer which covers the stone shrivels and dries and need not be removed before planting. The seeds ripen in the fall and may be sown at once. If spring sowing is preferred, the seeds should be stratified in sand and kept buried over winter in a well-drained place out of doors. To fill a box with alternating layers of sand and seeds and sink even with the surface of the ground is a good method of stratification. When filled, the box should be covered with a wire screen or boards to keep out mice, and then mulched with leaves or straw to protect the seeds from sudden changes in temperature.

The seeds should be sown in drills in good, rich soil, covered not more than half an inch deep, and the soil firmly pressed down upon them. Since hackberry seedlings grow only from 6 to 12 inches during the first sea-

son, they should be allowed to stand in the nursery until 2 years old before transplanting to the permanent site. The root system is branching and fibrous, and for this reason the hackberry is easily transplanted.

PLANTING.

The young trees should be set 4 to 6 feet apart. The planter will have to decide for himself whether it is more economical to purchase the seedlings or grow them in a home nursery. If the young trees cost more than \$5 per thousand, the planting of the hackberry for forest purposes is not likely to prove remunerative.

Hackberry will do well when spaced rather closely, and thrives either in mixtures or pure plantations. On the river bottom of the northern portions of the Middle Western States it forms a good associate with such intolerant species as cottonwood, walnut, and ash.

Hackberry is one of the best species for windbreaks on land too dry for cottonwood in western Minnesota, North and South Dakota, and northern Nebraska. The trees should be planted in a double row, with the rows 3 feet apart and the trees 4 feet apart in the row. The trees of the second row should be set opposite the middle of the spaces separating those of the first row.

On the plains of Oklahoma and Texas hackberry may be planted pure or in mixture with cottonwood, ash, walnut, black locust, honey locust, or Osage orange.

CULTIVATION AND CARE.

After a plantation has been established, cultivation must be prolonged sufficiently to prevent the native grasses from gaining a foothold. Weeds should not be permitted to crowd the young trees. The plantations must be carefully protected against fire and grazing.

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FOREST PLANTING LEAFLET 23.

RESERVE PLANTING.

SEED COLLECTING.

Methods of seed collecting vary greatly with different species and in different regions, and the judgment of the collector must always be exercised. The following instructions are necessarily general in nature, but may be suggestive, particularly to forest rangers who are to collect small quantities of seed for use in the rangers' nurseries.

WESTERN YELLOW PINE (*PINUS PONDEROSA*).

The cones mature late in September or during October. To secure the seed the cones must be collected soon after maturity, since they open soon afterward and let the seed fall. Where lumbering is in progress cones can be collected from the newly felled trees. In this case a curved hook fastened to a long pole will often be of service. The cones are usually near the ends of the limbs, and the picking should begin at the top of the tree and proceed downward. Standing trees must be climbed, and the cones may be gathered at once in buckets or stripped from the limbs and allowed to fall to the ground, to be gathered later. A pair of pruning shears on a long pole can be used to advantage in cutting off the well-filled ends of branches, from which the cones may be removed on the ground.

The cones will open in a few days if spread out in the heat of the sun in shallow layers on burlap, canvas, or sheeting. A thorough stirring will separate the seed from the opened cones, which can then be removed, leaving the seed on the sheets.

In many localities considerable quantities of cones may be secured from squirrel hoards. Cones from this source are usually of good quality, for they are gathered from the tops of trees and are well filled with seed.

JEFFREY PINE (*PINUS JEFFREYI*).

The directions given for collecting western yellow pine may be followed.

SUGAR PINE (*PINUS LAMBERTIANA*).

The cones should be collected early in September when they first begin to turn brown, since they open soon after ripening. Owing to the extensive lumbering of this species, cones may be collected from felled trees in some localities. Where this is not possible they must be gathered from the standing trees.

After being collected the cones will open in a short time if exposed to the heat of the sun, and the seed may then be easily shaken out.

LODGEPOLE PINE (*PINUS MURRAYANA*).

The cones mature in early fall usually during October. A large

number remain closed after ripening, so that collecting may be done at almost any time during the fall or in the winter lumbering season.

Cones may be easily gathered, however, from the standing trees by methods previously described (see p. 1).

Extracting seed from the cones requires special treatment. The cones must be subjected to artificial heat at a high temperature for several days before they will fully open. A series of trays of convenient size, built one above the other, may be placed about the sides of a room, in the center of which is a large wood stove. These trays can be made of 0.2-inch-mesh wire screen, nailed upon a frame of 2-by-4-inch pieces, and under each one canvas or burlap should be stretched to catch the seeds which will fall through when the cones open. The opening of the cones may be hastened by immersing them in hot water for a few moments before subjecting them to heat.

The cones should be spread on the trays in shallow layers, and during the day they should be subjected to a temperature of from 160° to 180° F. Each morning the cones should be thoroughly stirred and the seeds which fall through into the sheeting removed. In from four to six days all the cones will have opened, and they may then be replaced by a fresh supply.

Any small, well-constructed building will serve for a drying room. Owing to the risk of fire, however, it is not wise to dry the cones in a valuable building.

LIMBER PINE (*PINUS FLEXILIS*).

Limber pine cones usually mature during September and should be gathered from the standing trees, since the cones distribute the seed soon after ripening. Although the cones will open if exposed to the sun, it is more satisfactory to subject them to artificial heat as suggested for lodgepole pine. Less heat, however, is required.

RED FIR (*PSEUDOTSUGA TAXIFOLIA*).

The cones should be gathered as soon as they mature, usually during the latter part of September. If allowed to remain on the trees, they soon open and distribute the seed.

Cones may be picked from standing or felled trees as previously described (see p. 1).

When collected, the cones should be spread out in the sun, on sheets, canvas, or similar material. The heat of the sun will cause them to open in a few days, and the seed may then be extracted by thrashing or screening.

COULTER PINE (*PINUS COULTERI*).

The cones of the Coulter pine may be collected in late fall, usually during November or December. A limited amount of seed may be secured from cones which have fallen from the trees, but if any considerable amount is required the cones must be gathered from the standing trees either by clubbing or by the use of a knife fastened to a pole of convenient length. If the cones are stored they will gradually open

after a period of several months, but it will prove more satisfactory to subject them to artificial heat and shake the seed from the opened cones.

KNOBcone PINE (*PINUS ATTENUATA*).

The cones of the knobcone pine may be collected in the summer during June and July. They persist unopened on the branches for several years and the seed remains fertile for long periods. By climbing the trees the cones may easily be clubbed off with a long pole or stripped off with a hook fastened to a pole.

Artificial heat is most satisfactory for opening the cones, although they will open slowly if exposed to the heat of the sun.

When the cones are opened by the sun's heat the process may be hastened by immersing the closed cones in boiling water for one or two minutes and then spreading them out on sheeting in the direct rays of the sun. In a few days the cones will have opened sufficiently to release the seed. Care should be taken, however, that the cones are not allowed to remain more than a minute or two at most in the boiling water, for otherwise the vitality of the seeds will be destroyed.

BIGcone SPRUCE (*PSEUDOTSUGA MACROCARPA*).

The cones mature early in September and should be gathered at this time. The trees may be climbed with the aid of climbing irons, but it is very difficult to reach the cones, since they are found at the ends of the branches. A hook fastened to a pole of suitable length will be of great assistance. The cones can then be dropped to the ground and collected later.

Exposure to the sunlight will open the cones in a short time. They should be spread in single layers on sheeting and when opened should be thoroughly beaten to separate the seeds from the cone scales. In case the heat of the sun is inadequate the cones can be opened by artificial heat in the manner described for other species.

ENGELMANN SPRUCE (*PICEA ENGELMANNI*).

The cones must be collected from the standing trees immediately after ripening, usually early in October. The cones open readily when exposed to the heat of the sun, and then the seed can easily be thrashed out. Screening will be required, however, to separate the seeds from the cone scales which become loosened from the stem.

ALPINE FIR (*ABIES LASIOCARPA*).

The cones should be collected soon after they mature, usually early in October. It is necessary to gather them from the standing trees, using a hook fastened to a long pole to pull the cone-laden branches within reach. The cones will open when exposed to the sun on sheeting and must be screened to separate the cone scales from the seed.

SCREENING SEED FROM OPENED CONES.

Where it is difficult to separate the seed from the opened cones, some

sort of screening apparatus can be used to advantage. This may be made of a box of convenient size, fitted with a double bottom, the upper of wire screen of about one-fourth-inch mesh and the lower of burlap or canvas. This box should be suspended clear of the ground by wires and should be filled about half full of opened cones. A vigorous shaking will loosen the seeds from the cone scales, which will drop through the screen into the sheeting, leaving the emptied cones in the box above. In this manner considerable seed will be obtained which would otherwise be wasted.

The size of the mesh of the screen which forms the upper bottom should, of course, vary with the size of the seed of the various species. For all but the largest seeds, however, one-fourth-inch mesh will be large enough.

CLEANING SEED.

To detach the wings from the seeds is at best a tedious operation. It can be done by putting the seeds into a bag and beating them, after which the loose wings can be removed by running the seeds through a fanning mill fitted with suitable screens. If no fanning mill is available, the seeds may be winnowed by pouring from one receptacle to another in a current of air. The wings and light dirt are blown to one side, while the heavier seeds fall straight down. This process should be repeated until the seeds are fairly clean.

If the seeds are mixed with particles of resin, the cleaning must be done during the cooler time of day, when the resin is brittle enough to be easily screened out.

STORING THE SEED.

When cleaned the seed should be placed in sacks and stored in a cool, dry place. A storeroom or a well ventilated office will do. Protection from mice and rats may be secured by suspending the bags from the ceiling.

SUMMARY.

It is obvious that these general suggestions must be varied by the collectors to suit special cases. The main points to be borne in mind are these:

(1) Collect the cones before they have opened on the trees, but be sure the seeds are mature.

(2) Open the cones by exposure to the sun, if possible; if not, by the use of artificial heat.

(3) Clean the seed from wings and debris by the most convenient method, which must be varied according to the kind of seed and the apparatus available.

(4) Collect cones only from mature, well-formed trees.

(5) In collecting do not cut off leaders or injure valuable trees when it can be avoided.

(6) Store the seeds in sacks in a cool, dry place, away from mice

United States Department of Agriculture,

FOREST SERVICE.

FOREST PLANTING LEAFLET 24.

COTTONWOOD (*Populus deltoides*).

FORM AND SIZE.

The cottonwood is naturally a tall, straight tree and under favorable conditions may attain a height of 75 to 100 feet and a diameter of 2 to 3 feet. When grown in the open or in single rows it develops a large, wide-spreading crown and a short, heavy stem. In dense stands, however, the crowns become narrow and oblong and the stems long, slender, and free from branches.

The Carolina poplar, which is considered a horticultural variety of the common cottonwood, is widely used as a shade tree. It is not easily distinguished from the true cottonwood.

RANGE.

The eastern boundary of the natural range of cottonwood extends from central Quebec southward thru northwestern New England, western New York, and western Pennsylvania; thence, south of the Potomac River, thru the Atlantic States to western Florida. The western boundary extends from southern Alberta, in Canada, southward along the Rocky Mountains to northern New Mexico.

The cottonwood occurs usually in pure stands or in mixture with willow and other moisture-loving trees. On soils of the flood plains of the Mississippi River in western Kentucky and Tennessee, which are especially favorable, it forms a part of the mature hardwood forests.

For economic planting the range is confined to regions thruout the Middle West, where there is a permanent supply of water near the surface.

HABITS AND GROWTH.

The most favorable site for cottonwood is the alluvial soil along water courses, for the most important factor in its growth and development is the available moisture in the soil and not the fertility. Forest plantations of cottonwood require a situation in which the water table is within 10 to 15 feet of the surface. Individual trees or single rows, however, on account of their extensive root system, can maintain them-

selves in drier situations. So many failures have resulted from attempts to establish cottonwood groves on upland soils that it is usually considered impossible to grow the tree except in rows along highways and similar places. So planted, the trees are valuable for windbreaks and give good returns in fuel and repair material. However, more satisfactory results will be secured by planting in permanently moist situations if production of lumber is desired.

Abundant light is required for development, and young stands tend to become thin. The crown cover is frequently so sparse that grass and shrubs come in under the trees and check growth. This drawback can be prevented by underplanting the grove with shade-enduring trees.

Growth in early life is very rapid. Small trees in a single year may increase from 3 to 5 feet in height and from 1 to 3 inches in diameter. Between the ages of 10 and 15 years the rate of growth gradually lessens, and under certain conditions maturity is soon reached.

Cottonwood is comparatively free from insect pests, tho leaf insects occasionally do serious damage. In case of severe attacks application should be made to the Bureau of Entomology of the Department of Agriculture for information in regard to methods of control.

ECONOMIC USES.

The wood of cottonwood is light and soft. It is not strong, and it decays rapidly in contact with the soil. Regional factors of climate and soil cause marked differences in quality. In western Kentucky and Tennessee, for instance, the so-called yellow cottonwood furnishes a much better grade of wood than in the Missouri River region. The wood has a tendency to warp in seasoning, but this may be overcome by proper methods of piling.

Paper pulp, box boards, backing for veneer, the unexposed parts of furniture, wagon boxes, interior woodwork and boarding, and fuel are the principal products for which the wood is used. The increased value which the tree is gaining for these uses, coupled with the ease and rapidity with which it can be grown, renders it one of the important species for commercial planting in the Middle West. Its fuel value in some regions is especially high, since it furnishes a greater amount of wood in a given time than other species. In proportion to volume the relative heat production is, however, low.

Cottonwood is useful for protecting agricultural lands subject to annual overflow. A narrow belt of trees on the river side of such lands protects the fields from debris and checks the erosive action of the water. Plantations of cottonwood established on land between the river and the levee will not only protect the levee from damage by wave wash caused by the wind, but will also give large commercial returns. It is also particularly adapted for planting along canals, since the roots do not grow into the water.

METHODS OF PROPAGATION.

Cottonwood seeds abundantly and extends itself rapidly over newly made land along rivers. The seed ripens in May or June, and unless it falls on a favorable situation it quickly loses its ability to germinate.

Propagation by seedlings or cuttings may readily be carried on. Large numbers of seedlings annually spring up on the sand bars, where 1-year-old trees for establishing a plantation can be easily and cheaply procured. A plantation may be established rather more cheaply by cuttings than by seedlings. The cuttings should be made from 1 or 2 year old branches of vigorous trees. Cuttings one-half inch in diameter and 18 to 24 inches long are of desirable size for ordinary use. Much larger cuttings, however, can safely be used and are often desirable where the erosion is very severe.

PLANTING.

Seedlings or cuttings of the cottonwood should be set out in the spring as soon as danger from severe frost is past. In the Middle West this time ranges from the latter part of March to the first of May.

Seedlings may be quickly and cheaply planted by a man and a boy working together. With a spade the man makes an opening in the ground into which the boy slips a tree. The spade is then withdrawn and the soil about the tree firmed immediately, before the man advances for the planting of the next one.

Two-thirds of the length of the cutting should be below the surface of the ground, and on the portion above the ground there should be at least two or three good buds.

In planting groves on permanently moist situations the trees should be set 6 to 8 feet apart each way. This gives 1,210 or 680 trees per acre.

CULTIVATION AND CARE.

The growth of the cottonwood is so rapid where conditions are at all favorable that it is seldom, if ever, subject to the crowding or overtopping of less desirable species.

Plantations should not be used for pasturage for at least five years. Grazing animals not only eat the tender shoots and leaves, but expose and cut off the roots by trampling the ground around the trees.

Fire is one of the most serious enemies of this tree, both in planted groves and natural forests. Protection can readily be secured by plowing several furrows around the plantation. If the furrows are kept free from weeds, fire will be effectually kept out. Where this is not possible a path or fire lane entirely surrounding the plantation should be raked free of leaves and débris. In the spring and fall, when the danger from fire is greatest, the plantations should be kept under observation, and all fires should be extinguished immediately.

